HEYBURN STATE PARK
REVISED REUSE APPLICATION
TECHNICAL REPORT

Prepared for

Idaho Department of Parks and Recreation,
Boise, Idaho 83716

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1. SITE LOCATION AND OWNERSHIP

This report is being provided as part of the water reuse application for the Heyburn State Park (Park) Central Sewer Project per the Idaho Department of Environmental Quality (IDEQ) IDPA 58.01.17 rule. Heyburn State Park is a 5,500-acre recreational park which is proposing to construct a centralized sewer system to serve the existing and planned park facilities and private cabins located within. The facilities include lodges, maintenance buildings, campgrounds and a Visitor's Center.

1.1 Site Location

Heyburn State Park is the oldest park in the Pacific Northwest. Created in 1908, it is comprised of approximately 5,500 acres of land and 2,300 acres of water within Benewah County. The Park is located approximately 5 miles east of Plummer, Idaho within the NW¼ Section 12, T. 46 N., R. 4 W. in Benewah County, State of Idaho.

The Park includes three lakes: Chatcolet, Benewah, and Hidden Lake, with the shadowy St. Joe River meandering along the eastern boundary of the park. Heyburn is a natural park with a variety of different habitats. Ponderosa pines tower over grassy hillsides covered in wildflowers. On shadier slopes, cedar trees mix with hemlocks and white pines. On the edges of the lakes, the wetland/marsh areas are home to many types of wildflowers and plants. State Highway 5 travels through the Park in the east-west direction. See Figure 1-1 for site location map.

Currently the Park has several campground and common facilities in addition to 166 cabin sites. The majority of the cabins are privately owned on land leased from the State. The cabins are primarily concentrated in three areas: the Chatcolet area located on the west side of Chatcolet Lake in the northwestern part of the Park; the Rocky Point area located on the south side of Chatcolet Lake in the south-central part of the park; and, Hawley's Landing also located on the southern shore of Chatcolet Lake located approximately 1 mile west of Rocky Point and 1 mile south of the Chatcolet area. No commercial property currently exists in the Park. All sewage is currently handled via septic systems located throughout. Accordingly, there is no existing collection or treatment system in the service area.

The sewer service area is characterized by the three primary cabin areas, each located approximately 1 mile from the next. A few structures or campground areas located between these areas are also planned to be served by the new centralized sewer system. The elevation varies between these areas from approximately 2,150 feet above mean sea level (amsl) to approximately 2,300 feet. Land coverage is largely forest land throughout these areas.

The wastewater treatment facility (WWTF) will be on the west side of Chatcolet Lake (Figure 1-2). This facility will produce Class C reclaimed water which will be pumped to acreage in the southwestern part of the Park for irrigation purposes during the watering season. The irrigation site is at an elevation of approximately 2,800 feet. To manage the water for irrigation a storage basin will be located adjacent to the irrigated land.

During the non-irrigation months when watering is not required, the Class C reclaimed water will be stored in a lined pond.

The WWTF will be designed to blend in with the Park surroundings and have similar architecture as the recently designed Visitor's Center that is in construction.

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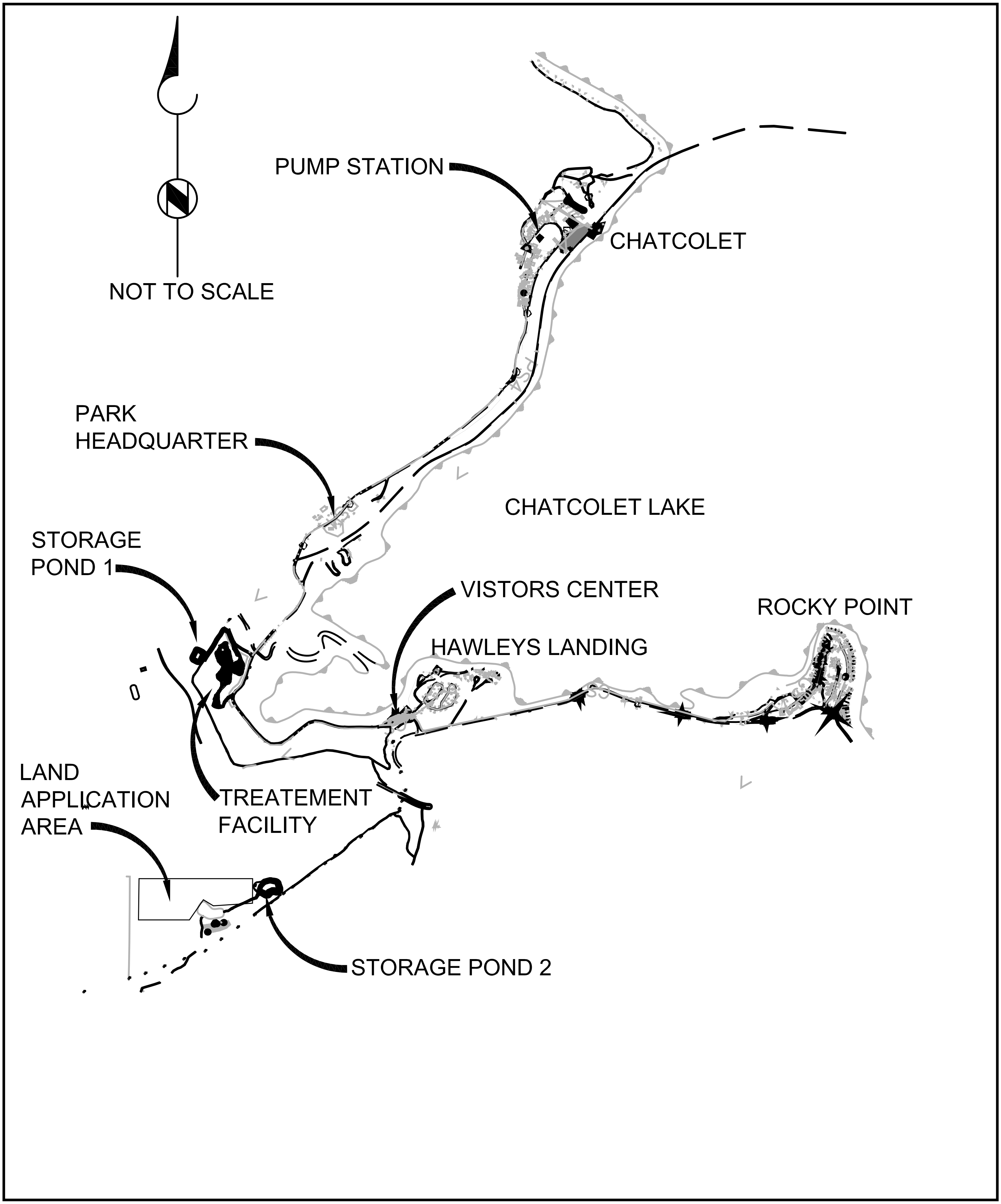
SITE LOCATION MAP

FIGURE 1.1



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OVERALL SITE PLAN

FIGURE 1.2

1.2 Existing Land Uses within One-Mile Radius

Kootenai County borders most of the property along the northern and western boundaries and the Coeur d'Alene Indian Reservation to the south, west and most of the north (Appendix A). The St. Joe River comprises most of the eastern boundary. The Park contains Chatcolet Lake, Benewah Lake and Hidden Lake and is in the midst of forested and/or agricultural land on every side of the Park property.

The WWTF and a storage pond will be located near the intersection of Plummer Creek and Lake Chatcolet (Figure 1-2). The area is forested with no other current use.

The land application site and a second storage pond will be located within the southwest portion of the Park, just north of State Highway 5 (Figure 1-2). The area is forested and has no other current use.

Public Water Sources: There are two public water wells within the Park boundary that are much further than 1,000 feet from the land application site. A new well is currently under development and will take the place of an existing well that is contaminated by connectivity to Plummer Creek.

Private Water Sources: There are no known private water sources within 500 feet of the land application site.

Canals/Ditches: There are no known canals or ditches near the land application site.

Dwellings: There are no dwellings within 300 feet of the land application site.

Areas of Public Access: The entire Park is fully accessible by the public. The land application site is in an area that does not have developed trails or roads. The closest public access point that is easily accessible is a parking lot for trail access. As shown on Figure 1-2, the land application site is north of the parking lot. A minimum 50-foot buffer from trails and the parking lot will be placed around the land application site.

Flood Plain Zones: The Federal Emergency Management Agency indicates that the location of the land application site is out of any flood zones. These results show that there is no need to address potential flooding issues.

1.3 Land Application Site Barrier

IDEQ guidance documents suggest fencing around the land application site (Appendix B). It is recommended that in lieu of fencing, signage be placed at intervals around the land application site warning the public of the risks. This approach will reduce conflicts with the wildlife population that may frequent the site and will be more in keeping with the wild forested setting that currently exists. All WWTF and storage pond facilities will be secured with chain link fencing to isolate the facilities from the wildlife and the public.

1.4 Site Ownership

The Park is owned by the Idaho Department of Parks and Recreation (IDPR). The Park is located approximately 5 miles from the City of Plummer. The cabins within the Park are on land leased from the state. Most of these leases are for a limited use of 180 days per calendar year.

A utility owned by the City of Plummer provides power to the Park. Two wells located within the Park provide domestic water throughout the Park. These wells are owned by the Park and maintained by Park staff. A new water distribution system was installed in 2006.

Brown and Caldwell contacted the City of Plummer to gage their interest in receiving and treating the wastewater for the Park. The City is in the midst of a wastewater treatment facility upgrade which will have to treat to very low levels of phosphorus since they discharge to Plummer Creek. This factor and due to the pumping and elevation distance between the Park and City, it was decided that a local treatment facility would be the most economical solution for the Park.

1.5 Permits/Licenses/Approvals

The following permits, etc., are or will be applied for:

Table 1.1 Permits, Licenses and Approvals

Permit or Approval	Jurisdiction	Status	Date
Wastewater Reuse Permit Application	DEQ	Filed	August 2008
Conveyance Bid Documents	DEQ	Conditionally Approved	February 2009
WWTF Bid Documents	DEQ	Conditionally Approved	February 2009
Idaho Transportation Department (ITD) Encroachment	ITD	Approved	September 2008

2. PROCESS DESCRIPTION

This section provides a general overview of the proposed WWTF and land application facilities. The section discusses the proposed sewers and service area, the preliminary layout and design of the proposed facility, and service area. Treatment includes screening, aerated lagoon treatment and disinfection with sodium hypochlorite to meet Class C treatment standards. After treatment, the Class C reclaimed water will be land applied via a pressurized irrigation system on a separate tract of land within the Park which is located remotely from the areas used by the public.

Figure 1-2 shows the proposed land use and sewer service area within the Park. Construction of the sewer collection system will begin first, construction of the treatment will follow, and hook up of the individual cabins to the collection system will conclude construction.

2.1 Wastewater Flow Projections

The Recommended Standards for Wastewater Facilities – Great Lakes – Upper Mississippi River Boards of State Sanitary Engineers (Ten States Standards) recommends a wastewater generation rate of 100 gallons per capita day (gpcd) for typical dwellings. This value is inclusive of base sanitary flow and normal infiltration and inflow (I/I) and used for each cabin site in the Park. To determine the planning level wastewater generation rate for other facilities in the Park, historical usage rates obtained from Park staff were used. As a conservative estimate, a value of 100 gpcd was applied to cabin dwellings based on an average population of 2.5 persons per residence consistent with IDEQ 58.01.03 "Individual/Subsurface Disposal Systems" rule Section 007.07a for a three-bedroom house. Therefore, the equivalent flow projection per cabin dwelling was estimated at 250 gallons per day (gpd).

The non-residential wastewater generation rates have been estimated using Park historical records. Based on these assumptions, average and peak wastewater flow projections for each type of facility are presented in Table 2.1.

Residential peak hourly wastewater flows (as shown in Table 2.1) have been calculated using a peaking factor provided in the Ten States Standards, and typical values applied in similar projects. This value depends upon the population contributing to the projected flow (P = population in thousands), and is calculated using the following equation:

$$\text{Peaking Factor} = Q_{\text{Peak Hourly}}/Q_{\text{average}} = (18 + P1/2) / (4 + P1/2)$$

While peak hourly flows will be used for sewer, screen and disinfection design, average daily flows are more important when designing wastewater treatment facilities. Given that the average daily flow estimates listed in Table 2.1 include a built-in allocation for I/I, the aerated lagoon wastewater treatment process will be designed for average daily flow of 68,000 gpd as shown in Table 2.1 below.

Table 2.1 Wastewater Flow Projections

Facility	Number of Facilities	Unit Flow Rate	Total Flow (gpd)	IDAPA 58.01.03
BASE BID				
Chatcolet:				
Cabins	55	250 gal/day	13,750	Single Family Dwelling
(Future) Float Homes	24	250 gal/day	6,000	Single Family Dwelling
Campgrounds	1 units with hook-ups 42 units without	125 gal/space	125	Travel Trailer Park with Sewer and Water Hook-up
CCC Restroom	Supports 42 unit campground	90 gal/space	3,780	Designated Camp Area Toilet and Shower Wastes
CCC Day Use Park Restroom	50 visits per day	5 gal/visit	250	Public Restroom Toilet
Marina Restroom	200 cars/day	2 persons/car 5 gal/person	2,000	Public Restroom Toilet
Dock Pump-out Station	10 private boats Resort Cruise boat	100 gal/week 100 gal/month	146	Historical Records
(Future) Concessions Stand	4,500 visitors/month 150 meals/day	13 gal/ meal	1,950	Conventional Food Service; Toilet and Kitchen Wastes
Other:				
Plummer Point Restrooms	Day use only, 200 visits/day	5 gal/person	1,000	Public Restroom Toilet
(Future) Campsites	50	90 gal/day	4,500	
Maintenance Building	2 employees	25 gal/employee	50	Office - No Showers
Employee Cabin	1	320	320	Single Family Dwelling
Volunteer RV sites near shop	4	125	500	Travel Trailer Park with Sewer and Water Hook-up
Base Bid Subtotal =			**34,317**	
ADD ALTERNATE NO. 1				
Other: Visitor's Center	2,500 visitors/mo. 5 offices	5 gal/person 25 gal/person	417 125	Public Restroom Toilet
Alt No. 1 Subtotal =			**542**	
ADD ALTERNATE NO. 2				
Hawley Landing:				
Cabins	12	250	3,000	Single Family Dwelling

Table 2.1 Wastewater Flow Projections				
Facility	**Number of Facilities**	**Unit Flow Rate**	**Total Flow (gpd)**	**IDAPA 58.01.03**
CG and Volunteer Sites	8 units with hook-ups 44 units without	125 gal/space	1,000	Travel Trailer Park with Sewer and Water Hook-up
Restroom Building	Supports 44 unit campground	90 gal/space	3,960	Designated Camp Area Toilet and Shower Wastes
Tent Camp Restroom	2 toilets, 10 spaces	65 gal/space	650	Camp Area Toilet Wastes only
Future Campsites	20 sites	35 gal/day	700	
RV Dump Station	30 dumps per day	40 gallons per use	1,200	Historical Records
Alt No. 2 Subtotal =			**10,510**	
ADD ALTERNATE NO. 3				
Rocky Point:				
Lodge with 3 Toilets and 2 Showers	6 rooms, 2 persons per room	35 gal/person	420	Overnight Accommodations with Central Toilet and Shower
CCC Restroom	4 restrooms, 400 visits per day	5 gal/person	2,000	Public Restroom Toilet
Other: Hansen's Haven	1	250	250	Single Family Dwelling
Alt No. 3 Subtotal =			**2,670**	
ADD ALTERNATE NO. 4				
Rocky Point: Cabins	80	250 gal/day	20,000	Single Family Dwelling
Alt No. 4 Subtotal =			**20,000**	
Subtotal for Current Facilities =			**55,643**	**Design Average Flow, GPD**
Subtotal for Future Facilities =			**12,450**	**Future Flow, GPD**
TOTAL =			**68,093**	**Future Design Average Flow, GPD**

Equivalent flow per ERU = 2.60 at completion of Development. (Equal to Total Average Flow Divided by Total Residences.)

Flows will fluctuate based on the time of year. This is a recreational area so the greatest flows will be in the summer months and the lowest flows will be in the winter months. To estimate the flow pattern during the year, the water usage at the Park during the year was evaluated. Below is the annual wastewater flow patterns estimated for the WWTF (Figure 2-1).

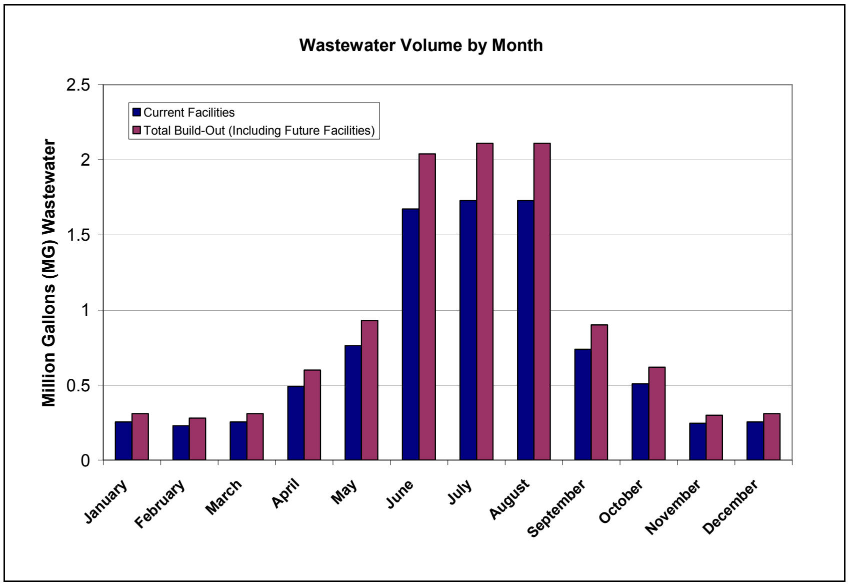


Figure 2-1. Wastewater Volumes by Month

2.2 Wastewater Treatment Components

2.2.1 Wastewater Treatment Overview

Sewage from each source will be collected through a collection system and pumped to the WWTF. The raw sewage will enter the WWTF at the Headworks Building. The sewage will be screened and flow via gravity to an aerated lagoon biological treatment system. Following treatment in the lagoons, the wastewater will flow to settling ponds where solids will accumulate and supernatant will be collected, disinfected with chlorine to produce Class C reuse quality water and pumped to storage ponds. During the irrigation months, treated effluent will be taken from the storage ponds and applied to land via a pressurized sprinkle irrigation system.

The facility will be provided with redundant process units and a standby generator capable of powering all of the critical process units. The screen system will not have redundancy, however it will be designed with a passive bypass.

2.2.2 Influent Screening

Screenings removal is the first step of the wastewater treatment process for the Park WWTF. Screenings consist of physically removing items using a screen with a clear space opening of 6 millimeters (mm) including, but not limited to, hair and other fibrous or filamentous material, plastics, rubber, wood, paper, leaves, rags, and tree roots. Some organic putrescible solids will be removed with the screenings. Screenings removed from wastewater will be washed to return the organic matter back to the treatment process.

The primary purpose for screens ahead of a lagoon treatment system is to remove floating unsightly, potentially odorous, material from the lagoon surface. A 6-mm clear opening screen is satisfactory in removing most all objectionable material found in domestic wastewater.

One screen will be installed with the capacity to handle the peak hour flow rate of the community at build out. The screening facility will include a passive bypass to overflow if the screen plugs.

The screenings will be washed, compacted, and discharged into a dumpster. The dumpster will be located in the screenings structure. Foul air treatment will be provided for the screening room in the building.

2.2.3 Lagoons

Multi-cell aerated lagoons will be constructed to treat the wastewater. A 60-mil welded high density polyethylene (HDPE) liner will be installed in each lagoon to prevent leakage. The lagoons will be constructed with 1:3 inside side slopes and 1:2 outside side slopes.

Two lagoons will be constructed for the biological treatment process. Each lagoon will be baffled into two operating cells. Each lagoon will be able to be bypassed to allow the treatment to be uninterrupted for maintenance purposes. Under normal operation at full capacity, the wastewater will flow through both lagoons in series.

Aeration equipment will be provided for each lagoon. The air can be manually controlled in each cell with the highest percentage of air delivered to the first cell in the series. Dissolved oxygen will be tested manually.

During the winter months, while influent flows are at a yearly low, one lagoon may be taken offline to reduce operational costs. To prevent freezing of the pipes and diffuser, the stagnant lagoon will be filled to a minimum of 2 feet above the air diffuser. The diffuser valve will remain slightly cracked during the winter months to allow a minimum air trickle to prevent backflow into the pipes.

Wastewater will exit the aerated lagoons via gravity and enter one of two settling ponds placed in parallel. Solids will settle in the settling ponds and supernatant will be collected as effluent to be pumped to one of two storage ponds. Following the aerated lagoons and settling ponds, a hypochlorite solution will be injected into the effluent conveyance line, and the effluent will be pumped to one of two treated water storage ponds, which will also be lined.

2.2.4 Disinfection

Wastewater will be treated to Class C reclaimed water standards prior to discharge. Disinfection is required to meet reclaimed criteria. Disinfection, when properly administered, prevents waterborne diseases caused by bacteria, viruses, and amoebic cysts.

The disinfection regulations for Class C reclaimed water require total coliform organisms not to exceed 23 per 100 milliliters. The design criteria are to provide sodium hypochlorite after the lagoon treatment to meet this coliform limit at the point of discharge into the storage ponds. Sodium hypochlorite (NaOCl) will be injected into the system for the strict purpose of disinfection as the flows move to Storage Pond 2. Effective mixing of chlorine solution with the wastewater will be achieved from the turbulent action of Pump 2. Conveyance from the operating effluent pump station suction pipes will allow for proper disinfection time as it travels to Storage Pond 2. From the upper storage pond, the reclaimed water will be pumped to the land application site. Operating conditions permit for another point of injection before Storage Pond 1. This allows for the possible occurrence of algae growth and odors that may occur during the summer months. The effluent from Storage Pond 1 will be disinfected again as it is conveyed to Storage Pond 2.

The required chlorine contact time is an important consideration when designing the treatment system. The following equation (Metcalf and Eddy, 2003) was used to find the required chlorine contact time given the various treatment parameters:

$$\frac{N}{N_O} = \left[\frac{(C_R t)}{b} \right]^{-n}$$

Where:
N_o= Number of organisms present before disinfect (MPN/mL)
N= Number of organisms remaining after disinfection time (MPN/mL)
CR= Chlorine dosage (mg/L)
t= Contact time (min)
n= Slope of inactivation curve
b= Value of x-intercept

Given a chlorine dosage of 15 milligrams per liter (mg/L) and a final maximum fecal coliform count of 23 most probable number per milliliter (MPN/mL), the minimum contact time required to properly disinfect is approximately 28 minutes. Based on an initial conservative estimated coliform count of 10^7MPN/100mL (Metcalf and Eddy, 2003), the contact time was calculated as follows:

Table 2.2 Required Chlorine Contact Time

Operating conditions:	Disinfection for given dosage, initial and final coliform bacteria	
Number of organisms present before disinfect (MPN/100mL)	N_o=	1.00E+07
Number of organisms remaining after disinfection time (MPN/100mL)	N=	23
Chlorine dosage (mg/L)	C_R=	15
Slope of inactivation curve	n=	2.8
value of x-intercept	b=	4
Contact time (min)	t=	28

Disinfection will occur in the conveyance pipe from the point of chemical injection to the Storage Pond 2. The chlorine contact time in the conveyance pipe is 2 hours and 45 minutes (Table 2.2). This contact time meets the above calculated required chlorine contact time needed to destroy disease-causing organisms.

Table 2.3 Actual Chlorine Contact Time

Operating conditions:	Conveyance line
Flow rate (gpm)=	50
Line diameter (inches)=	4
Length of pipe (feet)=	12600
Volume of conveyance line (ft^3)=	1100
Time of travel in pipe (min)=	165

Given that the effluent travel time is 2 hours and 45 minutes (Table 2.3), the number of organisms at the point of compliance (pump discharge into Storage Pond 2) is 1.24 MPN/100mL (Table 2.4). This meets Class C reclaimed water requirements of 23 CFU/100mL. This also meets Class B standards of 2.2 CFU/100 mL, thus Class C Buffer Zones are being conservative.

Table 2.4 Coliform Count		
Number of organisms present before disinfect (MPN/100mL)	N_o=	1.00E+07
Chlorine dosage (mg/L)	C_R=	15
Slope of inactivation curve	n=	2.8
Value of x-intercept	b=	4
Travel time in conveyance pipe (min)	t=	164
Number of organisms remaining after disinfection time (MPN/100mL)	N=	1.24

The operating chemical injection metering pump max capacity is 0.375 gallons per hour (gal/hr). The tank sizing and chemical pump flow are based conservatively at a volume of 375 gallons and a rate of 1 gal/hr, respectively. This equates to a total chemical operating time of 1,000 hours (41 days). This storage time is adequate for the life of NaOCl potency in the storage tank.

Table 2.5 Chemical Injection Feed Pump Flow Rates	
Effluent Pump Flow (gal/min)	50
NaOCl dosage (mg/L)=	15
NaOCl %=	12.5
NaOCl (mg/mL)=	120
NaOCl (mg/L)=	120,000
Chemical pump flow rate (gal/hr)=	0.375
Tank Capacity (gallons)=	375
Total Time of Storage (hr)=	1,000
Total Time of Storage (days)=	41

2.2.5 Reclaimed Water Pumping

For the Heyburn State Park WWTF, the reclaimed water must be pumped to the land application site for irrigation. An irrigation pump station will be installed near the upper storage pond. The pump station will draw water from the storage pond and disperse the water at the land application site.

2.2.6 Solids Handling

Solids will be stored in the settling ponds and disposed of on an as-needed basis. This is expected to occur every 5 years to 10 years.

2.2.7 Odor Control

The screenings processes will produce odorous air. Odorous air will require treatment in order not to adversely impact the surrounding community and the WWTF site environment. Foul air treatment system alternatives include a biofilter or a deep bed carbon absorber with activated carbon.

The most likely odor control system for the screening room in the Headworks Building will be a two-bed virgin activated carbon adsorber since activated carbon has a high capacity for removing volatile organic compounds (VOCs) and hydrogen sulfide (H2S). It is relatively simple to operate. The carbon absorber is more reliable than the biofilter because it is a physical system instead of a biological one.

2.3 Land Application Site

The reuse water will be pumped from the upper storage pond to a pressurized sprinkler irrigation system during the months of May through October. The irrigation system components will consist of spray type heads as typical in residential and commercial systems with valve boxes and distribution piping as required for reuse systems. Park staff will monitor the water application rates to ensure that land application occurs at agronomic rates.

The land application site is presently forest land which has been thinned to minimize fire danger. The underbrush and grasses in this area are also kept down for the same reason. Approximately 20.5 acres will be used for the land application area with additional adjacent areas identified for irrigation use if needed in the future or during wet periods.

Additionally, in winter months (October to March) the treated water will be stored. Since the historic flows during this time are low, two lined storage ponds will be constructed (Figure 1-2) to retain the water until the irrigation season begins.

3. SITE CHARACTERISTICS

3.1 Site Management History

The Park currently consists of several campground and common facilities in addition to 166 cabin sites. The majority of the cabins are privately owned on land leased from the State. The cabins are primarily concentrated in three areas: the Chatcolet area located on the west side of Chatcolet Lake in the northwestern part of the Park; the Rocky Point area located on the south side of Chatcolet Lake in the south-central part of the Park; and Hawley's Landing also located on the southern shore of Chatcolet Lake located approximately 1 mile west of Rocky Point and 1 mile south of the Chatcolet area. Currently, all sewerage is currently handled via septic systems located throughout. Accordingly, there is no existing collection or treatment system in the service area.

3.2 Climate Characteristics

The weather in St. Maries, Idaho is representative of the Park. Therefore, historical data for the St Maries (COOP) Weather Station were obtained through the Western Region Climate Center website, and were used for the basis of the design. The historical data available for this area were collected from August 1948 to June 2007, and are summarized as follows:

- Average total precipitation, 30.20 inches;
- Average total snowfall, 54.50 inches;
- Average annual maximum temperature, 59.09 degrees Fahrenheit (F);
- Average annual minimum temperature, 35.59 degrees F;
- Mean monthly annual temperature, 47.34 degrees F;
- Median annual extreme low temperature of -18.0 degrees F and an extreme high temperature of 103.0 degrees F;
- Number of frost free days ranges between 115 and 152; and,
- Growing degree days annually for base temperature 40 degrees F is 3,830.

3.3 Geology and Soils

The site is positioned at the northeastern margin of the Columbia River Plateau (CRP) physiogeographic province. In the vicinity of the site, Miocene volcanics of the Wanupum and Grande Ronde formations are overlain by younger (Oligocene to Miocene) unconsolidated sediments. The relatively horizontal volcanic units overlie folded and faulted Precambrian metasedimentary rocks of the Belt Supergroup, including various members of the Middle Proterozoic Wallace and Striped Peak formations. Geologic mapping in the region was conducted by Lewis, et al. (2000). The northeastern portion of the site, near Hawleys Landing, is relatively flat-lying and consists of Tertiary sediments directly overlying a thin succession of Miocene volcanics and/or Precambrian rocks. Pedee Hill, the topographic highland to the southwest of Hawleys Landing comprises a succession of Miocene volcanics several hundred feet thick. Elevation at the site ranges from approximately 2,150 feet amsl at Hawleys Landing to 2,815 feet amsl at the top of Pedee Hill.

The site includes land that is located in the following Land Office Grid System (LOGS) locations; South ½ of Southeast ¼ of Section 1, T 46 N, R 4 W; South ½ of Northeast ¼ of Section 11, T 46 N, R 4 W; and South ½ of Northwest ¼ of Section 12, T 46 N, R 4 W. A review of drilling logs obtained from Idaho Department of Water Resources (IDWR) suggests that in the vicinity of Hawleys Landing, unconsolidated sedimentary accumulations are clay-rich and extend to 56 feet below ground surface (bgs) and are underlain by at least 50 feet of basalt. On Pedee Hill, drilling logs from Section 11 indicate topsoil and clay accumulations up to 80 feet thick. These sediments are underlain by bedrock that is described on some driller's logs as basalt and on others as shale. These differing lithologic identifications occur in wells that are nearly adjacent to one another. The geologic map for the area suggests that the hill is composed of a minimum of several hundred feet of basalt overlying Precambrian metasedimentary rock. Therefore, the classification of the rock directly beneath the uppermost unconsolidated deposits as shale may be erroneous and possibly is a mis-identification of weathered basalt or ashfall horizons that may resemble mudstones or claystones.

Soil map units and descriptions are described from the Soil Survey of Benewah County Area, Idaho soil survey publication (USDA, 1980). The project area includes three major soil types. Near Hawleys Landing on the southwest corner of Chatcolet Lake, the soil consists of Blinn stony loam, 5 percent to 35 percent slopes. This soil is moderately deep and well drained, and occurs at elevations of 2,100 feet to 3,200 feet amsl. The soil forms in loess and volcanic ash overlying basalt colluvium. Surface runoff is immediate to rapid and the hazard of erosion is high. A typical soil profile includes light brown-gray neutral stony loam approximately 10 inches thick, underlain by pale brown stony loam up to 12 inches thick, and pale brown, neutral very stony loam up to 17 inches thick. Bedrock (basalt) occurs at a depth of approximately 39 inches bgs.

Soils on the hillcrest located southwest of Hawleys Landing include Taney silt loam, 3 percent to 7 percent slopes, and Lacy-Bobbitt stony loams, 5 percent to 35 percent slopes. The Taney silt loam covers the majority of the upland area that is located within the project area. The Taney soil unit is very deep and moderately well drained, has slow permeability and occurs on dissected loess hills at elevations that range from 2,300 feet to 3,200 feet amsl. It forms in loess with minor volcanic ash. The soil has slow permeability. A perched water table may occur at a depth of 18 inches to 30 inches bgs in spring. Surface runoff is medium, and the hazard of erosion is moderate. A typical soil profile includes gray to brown medium acidic silt loam up to 18 inches thick underlain by pale brown, medium acid silt loam 7 inches thick, and light gray medium acid silt approximately 3 inches thick. Buried subsoil is light yellow-brown silty clay loam that occurs to a depth of 60 inches or more. It is noted that the slow permeability and perched water table of the Taney silt loam are limitations to home development and septic tank absorption fields.

Lacy-Bobbitt stony loams, 5 percent to 35 percent slopes comprise a mix of Lacy stony loam and Bobbitt stony loam soil types. These soil types occur on mountain side slopes and terrace escarpments at elevations of 2,125 feet to 3,000 feet amsl. The Lacy soil is shallow, well drained, has moderate permeability, and is stony. It forms in basalt colluvial material with a small mantle of loess. Surface runoff is rapid and the hazard for erosion is high. A typical soil profile includes brown, neutral stony loam approximately 4 inches thick, underlain by dark brown, acid stony to very stony clay loam up to 10 inches thick. Bedrock (fractured basalt), occurs at a depth of 14 inches. The Bobbitt soil unit is similarly moderately deep, well drained and stony with moderate permeability. It likewise forms in basalt colluvium with a mantle of loess and volcanic ash. A typical soil profile includes brown, neutral stony loam approximately 4 inches thick, underlain by brown, neutral, very stony clay loam up to 17 inches thick. Basalt bedrock occurs at approximately 21 inches bgs. The characteristics of soils in this map unit limit homesite, road development, and septic drain field construction.

To obtain actual soil profiles, 22 excavation test pits were dug and observed by STRATA, Inc. (Appendix D). Infiltration testing was also performed to estimate percolation characteristics. The individual test pit field data sheets for the sprinkler irrigation site (Zone 2) are profiled in the Geotechnical Engineering Report. It was estimated that the site in-situ moisture content fluctuated from 16.9 percent to 29.2 percent. A percolation test was also performed in Test-Pit 19 of the land application zone which indicated an infiltration rate of 0.6 inches per hour.

Soil water holding capacity maps are depicted from the National Resource Conservation Service (NRCS, 1996). The project area includes soils that range from moderate to high water holding capacities (25-200mm).

The irrigation site slopes are an important aspect to irrigation effectiveness and efficiency. The average site slopes for the irrigation zones are listed in Table 3.1.

Table 3.1 Irrigation Site Slopes

Zone	Approximate High Elevation (feet)	Approximate Low Elevation (feet)	Horizontal Distance (feet)	Slope (%)
1	2795	2760	600	4.7
2	2790	2770	400	7.0
3	2790	2755	500	5.6
4	2800	2765	650	4.3
5	2805	2780	650	4.3

3.4 Surface Water

The site is located near the confluence of Plummer Creek and Pedee Creek. Plummer Creek bounds the site area to the north and flows east into Chatcolet Lake. Pedee Creek flows northward along the eastern site boundary into Chatcolet Lake. St. Joe River flows into Chatcolet Lake from the southeast. The elevation of Chatcolet Lake, as indicated on the United States Geological Survey (USGS) 7.5 Minute topographic quadrangle for Chatcolet, Idaho (1981) is 2,125 feet amsl.

Historical stream flow information was not available for Plummer Creek or Pedee Creek. Data from the USGS National Water Information System were available for the St. Joe River near Chatcolet, Idaho (USGS gaging station 12415140) for January 1991 to December 1992, November 2002 to December 2003, and March 2004 to present. Over the recording periods, the data indicate a maximum stream flow of 11,700 cubic feet per second (cfs) and a minimum of 320 cfs. On January 31, 2008, a stream flow volume of 3,400 cfs was recorded.

The reclaimed water for irrigation will be carefully managed and applied at agronomic rates to prevent additional waters from reaching any surface water. The rates will be adjusted to correspond with environmental conditions (temperature, rainfall, crop type and seasonal variations) which affect the watering needs to ensure the water is used by the crops.

3.5 Groundwater/Hydrology

A review of drilling logs obtained from IDWR suggests that sedimentary accumulations in the vicinity of Hawleys Landing are approximately 56 feet thick. On Pedee Hill, these accumulations are over 200 feet thick in wells completed to at least that depth. Clay forms the predominant sediment type within valley fills. The predominance of clay within the valley sediments further suggests regional deposition occurred in a quiescent, lacustrine environment.

4. WATERWATER CHARACTERIZATION, CROPPING PLAN AND LOADING RATES

4.1 Wastewater Characterization

4.1.1 Land Applied Wastewater

The Park's centralized sewer system will serve residential type housing units. Therefore, the wastewater characteristics are expected to be typical for domestic wastes in the area. The design includes storage of wastewater from October to the start of irrigation (beginning of March), and land application from March through September. The start up of the irrigation season will be dictated by spring conditions in the Park and will be outlined in the final Operations and Maintenance Manual. The proposed land application site is 20.5 acres based on the various monthly wastewater flow rates (Table 4.1). A total land application volume of 11.2 mg is expected from wastewater flows, generated from the existing park facilities and precipitation data. Design seasonal peak flow rates of 0.056 millions gallons per day (mgd) were used during the summer months (Table 2.1). Lower daily wastewater flow rates were used during the remaining months to account for off-season usage of the park system.

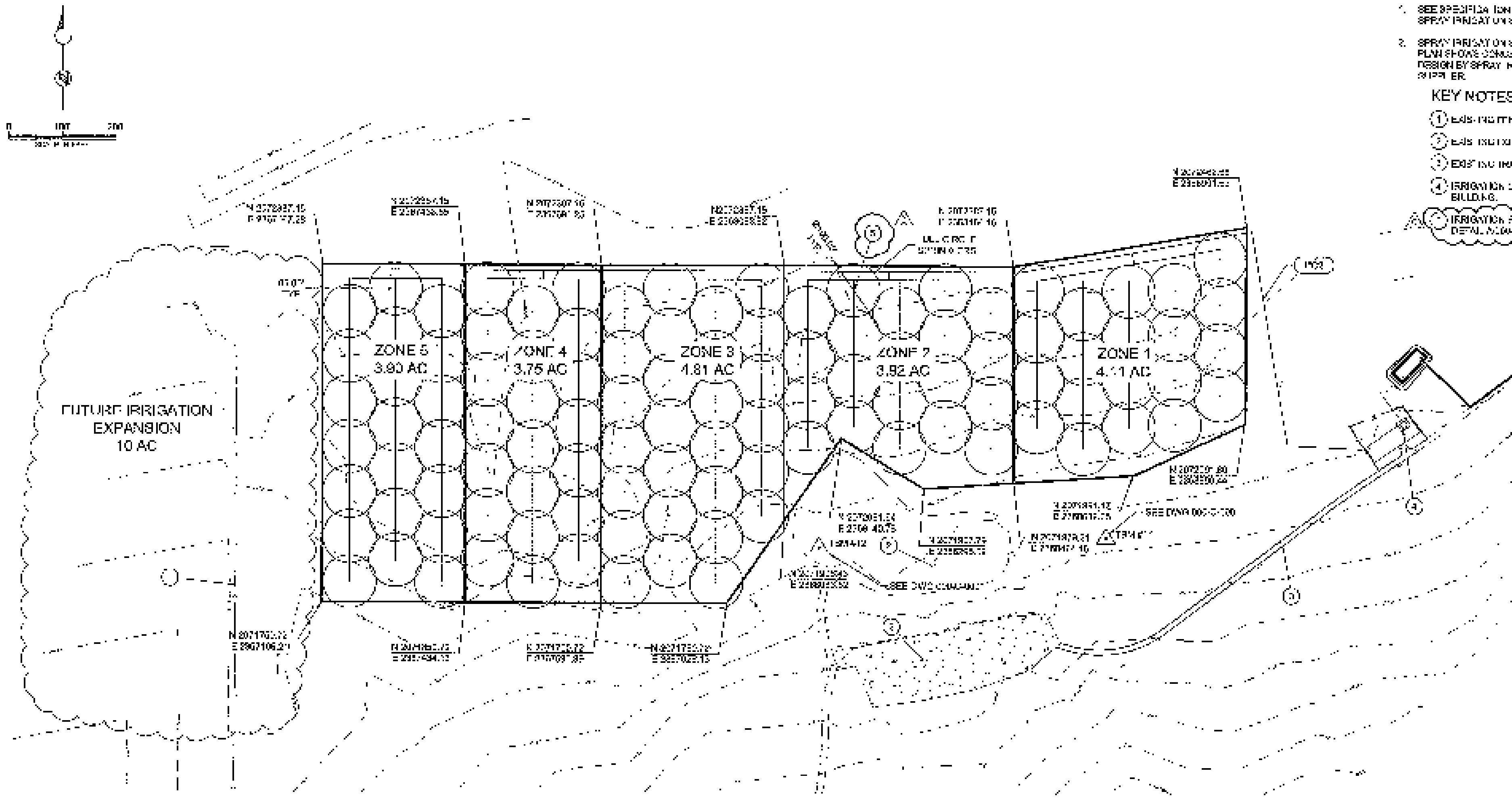
Table 4.1 Existing Facility Wastewater Flow Rates

Month	Days in Month	Wastewater Flow	Precipitation	Treatment Plant Effluent (Rain in Treatment Ponds + WW) Flow	Total Volume to Pond 1	Total Volume to Pond 2	Total Land Application Volume
		mgd	in/month	mgd	mg	mg	mg
January	31	0.008	3.91	0.011	0.42	0.11	
February	28	0.008	3.1	0.011	0.36	0.09	
March	31	0.008	2.68	0.010	0.37	0.08	
April	30	0.016	2.28	0.018	0.05	0.61	
May	31	0.025	2.49	0.028	0.05	0.93	
June	30	0.056	1.96	0.058	0.04	1.80	
July	31	0.056	1.28	0.057	0.03	1.81	
August	31	0.056	1.13	0.057	0.02	1.80	
September	30	0.025	1.4	0.026	0.03	0.83	
October	31	0.016	2.02	0.019	0.04	0.64	
November	30	0.008	4.13	0.011	0.08	0.46	
December	31	0.008	4.25	0.011	0.43	0.12	
Totals					1.91	9.28	11.2

When future build-out flows are included, the design seasonal peak flow rate is 0.068 mgd with a total land application volume of 13.14 mg (including existing facilities, future facilities, and precipitation). By the time these future facilities are constructed, several years of operational data will have been gathered. This additional information will give a more accurate assessment of the annual flows and the size of land application area needed. At the proposed land application site, an additional expansion area of approximately 10 acres has been identified for the land application system to accommodate any expansion needs for the system. At the same time, it is likely that the proposed 20.5 (Figure 4-1) acre land application site will be more than enough to support the flows from both the existing facilities and future facilities. The design flow rate is expected to occur primarily during weekend peaks and will likely not be an every day occurrence, resulting in lower annual flows than projected.

Table 4.2 Build-Out Wastewater Flow Rates

Month	Days in Month	Wastewater Flow	Precipitation	Treatment Plant Effluent (Rain in Treatment Ponds + WW) Flow	Total Volume to Pond 1	Total Volume to Pond 2	Total Land Application Volume
		mgd	in/month	mgd	mg	mg	mg
January	31	0.01	3.91	0.01	0.47	0.11	
February	28	0.01	3.1	0.01	0.41	0.09	
March	31	0.01	2.68	0.01	0.42	0.08	
April	30	0.02	2.28	0.02	0.05	0.72	
May	31	0.03	2.49	0.03	0.05	1.09	
June	30	0.068	1.96	0.07	0.04	2.17	
July	31	0.068	1.28	0.07	0.03	2.19	
August	31	0.068	1.13	0.07	0.02	2.18	
September	30	0.03	1.4	0.03	0.03	0.99	
October	31	0.02	2.02	0.02	0.04	0.75	
November	30	0.01	4.13	0.01	0.08	0.51	
December	31	0.01	4.25	0.01	0.49	0.12	
Totals					2.13	11.01	13.14



GENERAL NOTES

1. SEE SPECIFICATION SECTION FOR SPRAY IRRIGATION SYSTEM DETAILS.
2. SPRAY IRRIGATION SYSTEM SITE PIPING PLAN SHOWS CONCEPTUAL LAYOUT. FINAL DESIGN BY SPRAY IRRIGATION SYSTEM SUPPLIER.

KEY NOTES:

1. EXISTING TANK.
2. EXISTING HORSE DROP OFF.
3. EXISTING TRAIL.
4. IRRIGATION CONTROL BUILDING.
5. IRRIGATION RISER, TYP. SEE DETAIL

CONFORMED DOCUMENT - THIS DOCUMENT WAS COMPILED FROM ALL BID PERIOD INFORMATION RELATIVE TO THIS SHEET. THE ENGINEER IS NOT RESPONSIBLE FOR THE ACCURACY OF THE INFORMATION HEREIN. THE ORIGINAL BID DOCUMENTS ARE THE CONTRACTUAL DOCUMENTS FOR THIS PROJECT AND IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO UPDATE THOSE DOCUMENTS AS NECESSARY TO KEEP AN ACCURATE RECORD OF THE CONSTRUCTION. ORIGINAL DRAWINGS SIGNED BY THE DESIGN ENGINEER. CONFORMED DRAWINGS STAMPED AND SIGNED BY THE PROJECT MANAGER.

4.2 Cropping Plan

A silviculture plan was prepared to develop the cropping requirements for this site. Cropping will be completed per the recommendations in the report (see Appendix C).

4.3 Hydraulic Loading Rate

4.3.1 Monthly Water Balance for Lagoon Storage

Storage ponds 1 and 2 are designed to hold volumes of 1.75 mg and 2.41 mg, respectively. An estimated total storage volume requirement of 1.70 mg and 2.37 mg (Table 4.3) has been calculated for Storage Pond 1 and 2, respectively. Pond 1 pump time is projected to run form April through September

No irrigation can occur in October, thus by the end of September all storage ponds must be emptied. Based on irrigation and pumping rates (see Section 4.3.2), the cumulative storage volume will approximately be zero (±50,000 gallons) by the end of the land irrigation season.

Table 4.3 Existing Facility Lagoon Storage Balance

Month	Total Volume to Pond 1	Total Volume to Pond 2	Process Required Pumping Time for PMP-02 (2)	Pond 1 Drain Pumping Time for PMP-02 (2)	Volume Drained From Pond 1	Cumulative Volume in Storage Pond 1	Cumulative Volume in Storage Pond 2
	mg	mg	hr/day	hr/day	mg/mo	mg	mg
January	0.418	0.113				0.974	1.332
February	0.359	0.090				1.334	1.422
March	0.366	0.078				1.700	1.383
April	0.046	0.607	6.0	8	0.720	1.026	2.373
May	0.050	0.926	9.2	0	0.000	1.077	2.369
June	0.040	1.802	19.4	4	0.360	0.756	2.056
July	0.026	1.813	19.1	4	0.372	0.410	0.985
August	0.023	1.803	19.0	4	0.372	0.061	0.603
September	0.028	0.830	8.8	1	0.090	-0.001	-0.052
October	0.041	0.641	6.3			0.041	0.641
November	0.083	0.455				0.124	1.096
December	0.432	0.123				0.556	1.219

As build-out is approached, anticipated wastewater volumes will increase, thus increasing the duration and months of pumping time (Table 4.4). Pond 1 pump times will begin operation earlier in the season, beginning in March and ending in September. The cumulative storage in both ponds will again drop back to zero (±50,000 gallons).

Table 4.4 Build-Out Lagoon Storage Balance							
Month	Total Volume to Pond 1	Total Volume to Pond 2	Process Required Pumping Time for PMP-02 (2)	Pond 1 Drain Pumping Time for PMP-02 (2)	Volume Drained From Pond 1	Cumulative Volume in Storage Pond 1	Cumulative Volume in Storage Pond 2
	mg	mg	hr/day	hr/day	mg/mo	mg	mg
January	0.474	0.113				1.086	1.498
February	0.410	0.090				1.496	1.587
March	0.422	0.078		2	0.186	1.732	1.735
April	0.046	0.715	7.216	4	0.360	1.418	2.473
May	0.050	1.094	10.984	0	0.000	1.468	2.404
June	0.040	2.169	23.467	0	0.000	1.508	1.872
July	0.026	2.192	23.173	8	0.744	0.790	0.856
August	0.023	2.182	23.113	8	0.744	0.069	0.760
September	0.028	0.992	10.572	1	0.090	0.007	0.042
October	0.041	0.753	7.465			0.041	0.753
November	0.083	0.509				0.124	1.262
December	0.488	0.123				0.612	1.385

4.3.2 Irrigation Hydraulic Loading Rates

Wastewater, again, will be stored from October through late March and irrigation will begin in late March and terminate in September. Quantities collected in October through April will be stored and distributed at the land application site with the volumes in March through October. The loading rates were calculated from the Kimberly, University of Idaho Precipitation Deficit Data (University of Idaho, 2006, Plummer Station). An irrigation efficiency of 75% was given for a solid set sprinkler system (IDAPA 58.01.17). A hydraulic loading rate of 13.47 MG has been estimated for the land application site (Table 4.5).

Table 4.5 Hydraulic Loading Rate					
Month	Days in month		Volume	Hydraulic Loading Rate	Maximum Volume (1)
in/ month		inches	mg	gal/acre/day	mg
March	31	0.20	0.11	174	0.14
April	30	0.53	0.29	478	0.38
May	31	1.43	0.78	1,253	1.04
June	30	3.91	2.12	3,539	2.83
July	31	5.69	3.09	4,984	4.12
August	31	4.31	2.34	3,775	3.12
September	30	2.54	1.38	2,299	1.84
Total				16,502	13.47

Note: (1) Assumes 20.5 acres and a 75 percent irrigation efficiency rate

Existing facility and build-out hydraulic loading rates are based on maximum sprinkler rate, available irrigation acreage and the duration of irrigation per day. The hydraulic loading rate for the existing facility is estimated at 13,445/acre/day, and the maximum hydraulic rate is 16,502 gallons/acre/day (Table 4.6). At the time of build-out a hydraulic loading rate of 15,640 gallons/acre/day is expected (Table 4.7). Both the existing and build-out hydraulic loading rates are below the maximum hydraulic loading rate.

Typically, wastewater design flows are planned conservatively, thus the probability of reaching design seasonal peak flows is low. Designing the land application site at 20.5 acres is a conservative design approach. If early monitoring performed by operation staff suggests flows are equal to or greater than design flows, as stated earlier, an additional 10 acres has been allocated adjacent to the land application system. The area of land can be optimized (remain the same/slightly expanded) when actual wastewater flow data has been collected.

Table 4.6 Existing Facility Hydraulic Loading Rate

Month	Irrigation Rate from Pond 2	Irrigation	Hydraulic Loading Rate(1)	Irrigation Volume from Pond 2	Max Hydraulic Loading Rate	Maximum Volume (1)
	gpm	hr/day	(gal/acre/day)	mg	(gal/acre/day)	mg
March	125	0.5	137	0.12	174	0.14
April	125	1.5	412	0.34	478	0.38
May	125	4	1098	0.93	1253	1.04
June	125	11	3018	2.48	3539	2.83
July	125	14	3841	3.26	4984	4.12
August	125	11	3018	2.56	3775	3.12
September	125	7	1921	1.58	2299	1.84
Totals			13445	11.2	16502	13.47

Note: (1) Assumes 20.5 acres and a 75 percent irrigation efficiency rate

Table 4.7 Build-Out Hydraulic Loading Rate

Month	Irrigation Rate from Pond 2	Irrigation	Hydraulic Loading Rate(1)	Irrigation Volume from Pond 2	Max Hydraulic Loading Rate	Maximum Volume(1)
	gpm	hr/day	(gal/acre/day)	mg	(gal/acre/day)	mg
March	125	0.5	137	0.12	174	0.14
April	125	1.5	412	0.34	478	0.38
May	125	5	1372	1.16	1253	1.04
June	125	12	3293	2.70	3539	2.83
July	125	17	4665	3.95	4984	4.12
August	125	13	3567	3.02	3775	3.12
September	125	8	2195	1.80	2299	1.84
Totals			15640	13.09	16502	13.47

Note: (1) Assumes 20.5 acres and a 75 percent irrigation efficiency rate

There will be no supplemental irrigation water for the land application site.

4.4 Constituent Loading Rate

The approach for the design is for the treated water to be stored and used for irrigation purposes. This eliminates any direct or indirect discharge to the surrounding surface waters. During the dry months the reclaimed water would be used to irrigate land at the land application site in the Park. During the non-watering periods, the reclaimed water would be stored until the irrigation water is needed.

The predicted constituent loading rates based on the full build-out capacity of 68,000 gpd and a land application site of 20.5 acres are presented in Table 4.8.

Table 4.8 Constituent Loading Rate Per Year

Month	Inches	N[1] (mg/l)	N (lbs/acre)	P[1] (mg/l)	P (lbs/acre)
May	4.32	14.3	13.9	3.25	3.2
June	4.97	14.3	16.1	3.25	3.6
July	5.14	14.3	16.6	3.25	3.8
August	5.14	14.3	16.6	3.25	3.8
September	4.95	14.3	16.0	3.25	3.6
Total	28.59		92.3		21.0

[1] Nitrogen and phosphorus calculations assume dilution from precipitation collected in treatment and storage ponds and are weighted averages. Total precipitation volume is 2.9 million gallons or 19% of the total yearly volume. Nitrogen concentrations vary from 1 mg/l in the winter to the 20.1 mg/l in the summer based on process calculations. The phosphorus effluent concentration is assumed to be 4 mg/l before dilution, however it is difficult to predict. Adjustments to land application rates and/or area may be required based on monitoring the operation during each year of operation. Additional land application area is available should the land application site require expansion.

mg/l – milligrams per liter *lbs/acre – pounds per acre*

5. SITE MANAGEMENT

This section addresses necessary regulatory and ongoing operations and testing requirements of the wastewater system to ensure performance standards are being maintained.

5.1 Compliance Activities

There are a number of federal, state and local regulations that govern the design, construction and operation of wastewater treatment systems. A National Pollutant Discharge Elimination System (NPDES) permit is not required since the discharge from the WWTF is (1) not to any surface water and, (2) will meet Idaho Class C quality requirements in accordance with IDAPA 58.01.17 for reuse within the Park for irrigation.

To protect public health and prevent pollution of surface and ground waters, Idaho's Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater (IDAPA 58.01.17) require anyone wishing to land-apply wastewater to obtain a Wastewater Reuse Permit (WRP) before constructing, modifying, or operating a wastewater-land application facility in the state. The permit limits the volume of wastewater that may be land applied based on scientific health standards and requires monitoring to assure the standards are not exceeded.

IDPR will staff the operation of the collection system, WWTF and the land application system during startup.

5.2. Seepage Rate Testing

The aerated lagoons, settling ponds, and storage ponds will be constructed of dual 60 mil polyethylene liners. Seepage testing will be performed in accordance with IDAPA 58.01.16.493.

5.3 Site Management Plans

Buffer Zone Plan

Buffer Zone Plans are associated with land application of wastewater treated to lower than Class A standards. Since the WWTF will be treating to Class C standards, a Buffer Zone Plan is required. The Buffer Zone Plan includes establishing a 50-foot buffer around the perimeter of the land application site with signage located at 150-foot intervals indicating to the public the area is irrigated with reclaimed wastewater which may pose a health risk and therefore, they are to keep out of the area.

Grazing Management Plan

Grazing Management Plans are required for land application operations associated with livestock grazing operations. Heyburn State Park does not have livestock grazing operations, but may have transient game animals frequenting the land application area. The site will be monitored for game activity and any impact that it has on the amount of irrigation applied to the site.

Nuisance Odor Control Plan

Nuisance Odor Control Plans are associated with land application of wastewater treated to lower than Class A standards. The most likely location for nuisance odors will be at the Headworks Building. A carbon scrubber will be used to treat odorous air from the screenings room in the Headworks Building.

Waste Solids Management Plan

As described in Section 2.2.7, the solids handling will be on an as needed basis. When the settling ponds show an accumulation of solids which need to be removed, the settling ponds will be drained. The solids will be hauled to an adequate disposal site. Either an approved landfill or land application site will be used for this purpose.

Total Dissolved Inorganic Solids Management Plan

Groundwater impacts are not anticipated at the land application site. Agronomic land application rates will be utilized. Groundwater was not encountered during the geotechnical investigation.

Runoff Management Plan

To manage runoff of reclaimed water within the Park, the water will be managed by operations staff to ensure water application rates are consistent with agronomic rates and the irrigation system components are well maintained to function as intended.

5.4 Monitoring

The flow rate of land applied water will be measured using a flow meter on the discharge of the irrigation pump station. The flow meter will record all flows and calculate total volumes for each day of irrigation. IDPR staff will monitor the total water volumes applied to the land application site. Constituent concentrations will be recorded through monthly sampling of the WWTF effluent. The effluent samples will be collected and the treated volume of water will be recorded. The constituent loading rates will have to be calculated based on the effluent concentrations measured at the plant and the volume of wastewater applied at the land application site. Table 5.1 presents the proposed monitoring schedule.

Table 5.1 Proposed Monitoring Schedule

Frequency	Location	Sample Type	Test Parameters
Weekly	WWTF	Grab	Effluent Chlorine
Monthly	WWTF	Grab, Data Recording	Influent and Effluent Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), Nitrogen, Phosphorus. Influent Flow Volume
Daily	Land Application Site	Data Recording	Applied Volume Soil Moisture
Annually	WWTF and Land Application Site	Data Recording	Hydraulic Loading Constituent Loading
Five Years	Land Application Site	Soil Auger	Nitrogen and Phosphorus

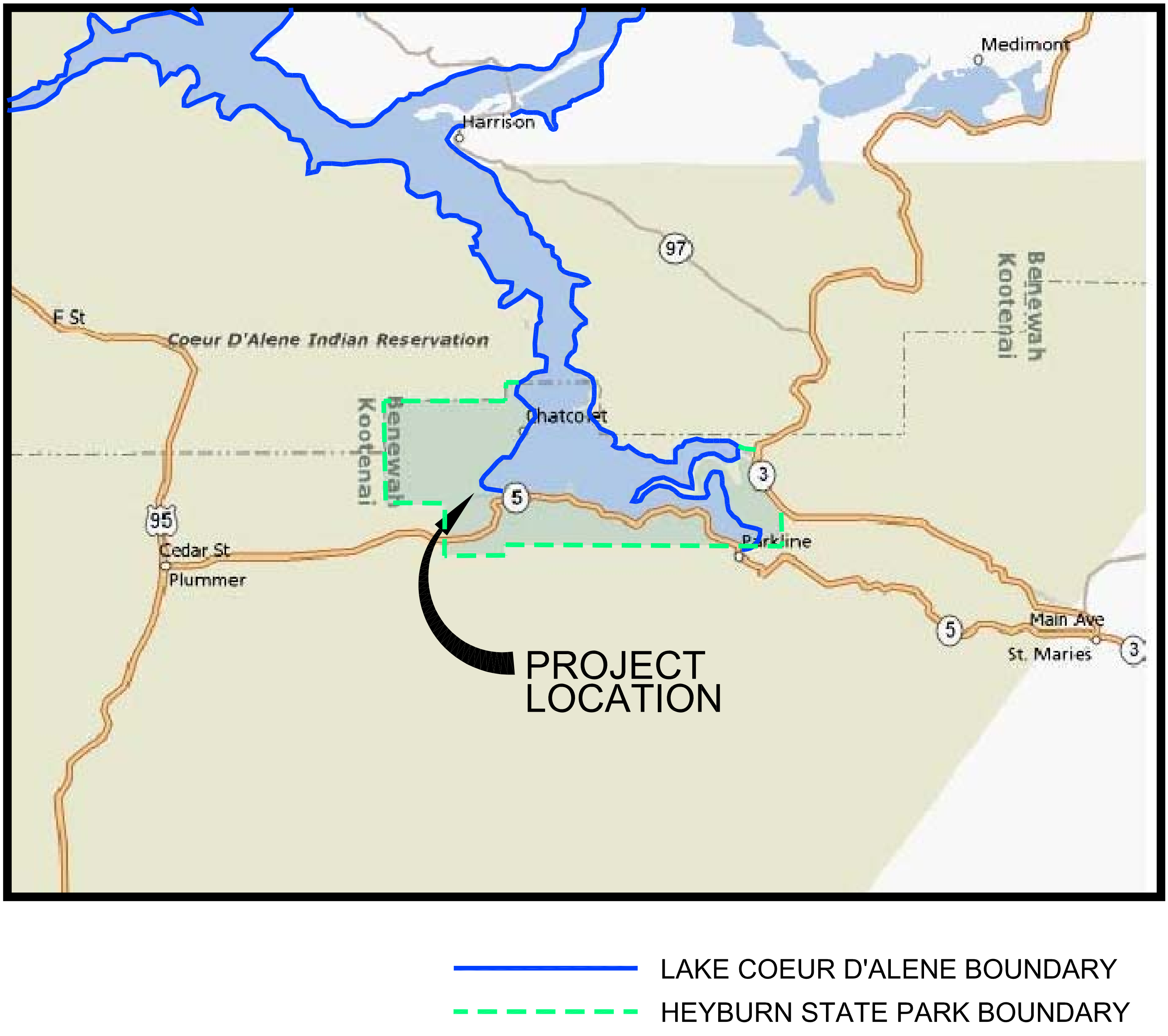
5.5 Site Operations and Maintenance

The WWTF will be operated and maintained by a licensed operator as required per the Idaho Wastewater Treatment Plant Classification Worksheet. An operator has not yet been selected for the facilities. IDPR will either train or hire a licensed operator or outsource the operations to a contractor.

APPENDICES

APPENDIX A: VICINITY MAP

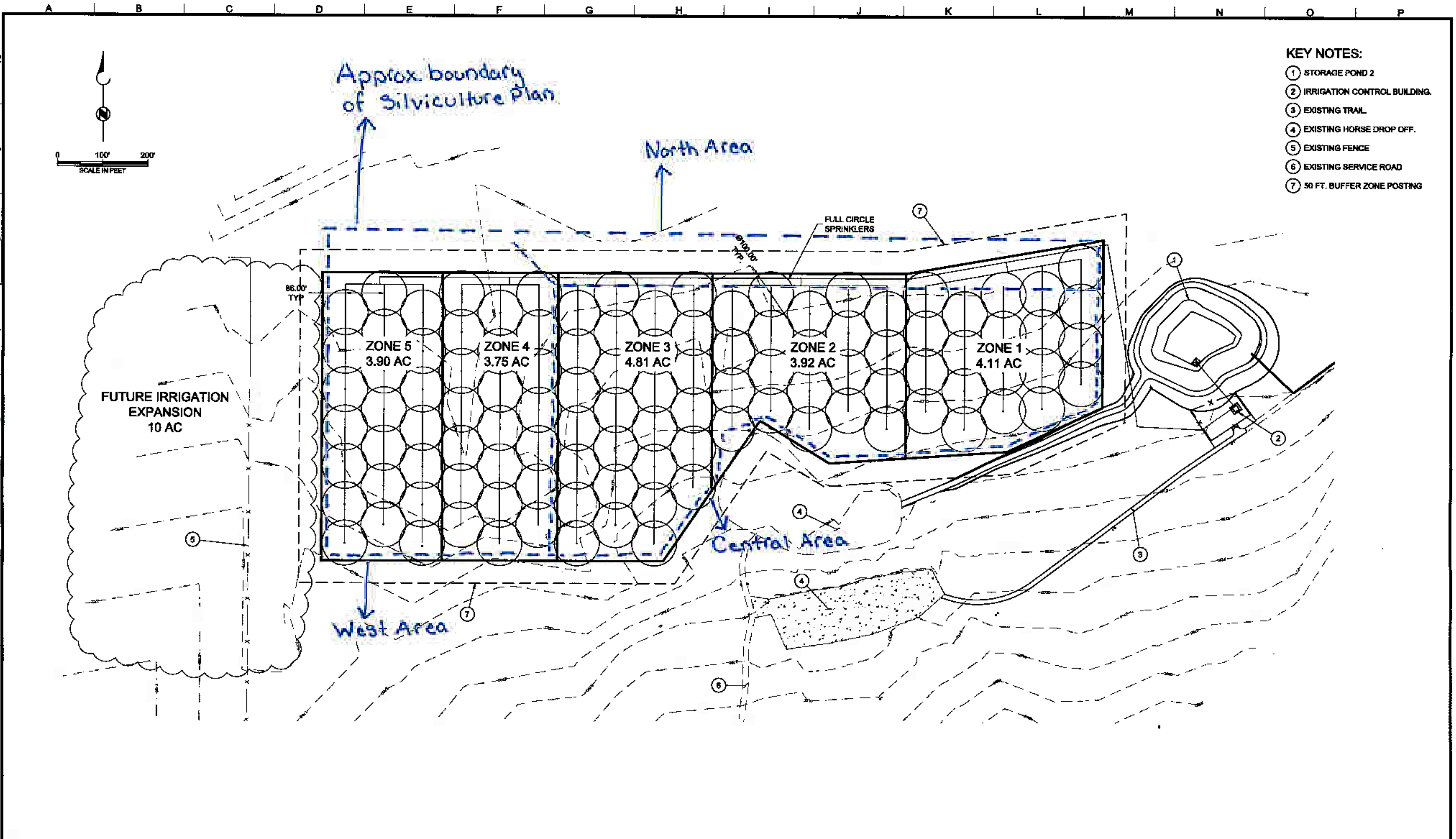
SITUATED IN THE NW 1/4 OF SECTION 12
TOWNSHIP 46 NORTH, RANGE 4 WEST, B.M.



BROWN AND CALDWELL
BOISE, IDAHO

VICINITY MAP

APPENDIX B: FACILITY SITE MAP



BROWN AND CALDWELL
BOISE, IDAHO

SUBMITTED: ______ DATE: ______

APPROVED: ______ DATE: ______

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2" - SCALE ACCORDINGLY)

DESIGNED: AMJ
DRAWN: SDC
CHECKED: DGS
CHECKED: SPW
APPROVED: SPW

EXTERNAL REFERENCE FILES

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

IDAHO DEPARTMENT OF PARKS AND RECREATION

HEYBURN STATE PARK
CENTRAL SEWAGE COLLECTION AND TREATMENT SYSTEM

FACILITY SITE MAP

FILENAME 133637-300-C-008
BC PROJECT NUMBER 133637
CLIENT PROJECT NUMBER 310670
DRAWING NUMBER 300-C-008
SHEET NUMBER 50 OF 110

JUNE, 2009

APPENDIX C: SILVICULTURE PLAN

REPORT FOR THE HEYBURN STATE PARK PROPOSED APPLICATION OF WASTE WATER ON A CONIFEROUS FOREST AREA

UTILIZING EXISTING CONIFEROUS FOREST FOR WASTE WATER TREAMENT

A REPORT DEVELOPED BY IDAHO PANHANDLE FORESTRY CONSULTANTS
Ralph A. and Robert A. Wheeler

June 2008

TABLE OF CONTENTS

INTRODUCTION

The Brown and Caldwell Engineering Firm subcontracted the Idaho Panhandle Forestry Consultants (I.P.F.) to inventory an existing stand of timber and related forest resources located on Heyburn State Park property within the NW¼ Section 12, T. 46 N., R. 4 W. in Benewah County, State of Idaho.

This site evaluation included conducting an assessment of the potential for application of waste water from a proposed sewage treatment plant, and submission of a comprehensive report summarizing the stand analysis and conclusions regarding the application of secondary waste water.

Based upon recent research with the application of waste water on forest stands and experience with similar projects, this report provides specific recommendations regarding the potential of the trees and associated vegetation found on the site for the bio-remediation (treatment) of semi-treated (secondary) waste water. The soil, trees, and associated vegetation provide a means for final filtration of waste water through the combined effects of soil drainage, root uptake, evaporation, and transpiration from both trees and other vegetation.

Based upon increment borings taken from the plantation trees, Ponderosa pine (*Pinus ponderosae*), and evaluation of site evidence indicate that the site was machine planted in 1967 with a tree spacing of 10 foot by 10 foot. Portions of the area were recently treated by removal of undesirable vegetation including understory Douglas fir (*Pseudotsuga menziessii*). The present tree spacing in the plantation has been determined to be approximately 22 foot by 22 foot. The average stand stocking is now near that for a mature stand of timber. The growth rate on the residual trees is exceptional; however, there is increasing between-tree competition in addition to existing ground vegetation.

There has been no measurable release in diameter growth on the residual trees following the recent stand treatment based on increment borings, however, trees will increase their root system and crowns first following release and with sufficient water and nutrients will begin to display Botha height and stem diameter growth response. The brush has re-sprouted and now varies in abundance, height, and density based on the year of treatment. This understory vegetation can also provide valuable assistance in treatment of waste water and protection of the site.

Strips of timber near the center running north and south, along the northern side, and along the east side have not been treated. The untreated areas have dense understory vegetation, more merchantable timber, more Douglas fir, occasional mature Ponderosa pine and lodge pole pine (Pinus *contorta*). There is also an increase in mortality in these areas. Nearly all Ponderosa pines on approximately 1 acre in the north strip have recently been killed by bark beetles, possibly Ips (Ips *pini*). This may have resulted from incomplete disposal of piled debris on adjacent areas.

The 1980 Benewah County Soils Survey classified the soils as Taney Silt Loam. These soils are deep with a good duff layer, but, have a layer of heavy clay at about 34 inches that can cause a perched water table. Examination of planted Ponderosa pine root systems indicates the roots are extending down through this layer utilizing moisture and nutrients from below. Test indicates the soils are now more basic then at the time of the soils survey. Nitrogen is inadequate and may be the main factor in competition with site vegetation. Phosphorus was found to be adequate or better in the upper 2 feet, but, inadequate at 3 foot. It appears trees are obtaining much of the needed nutrient by recycling minerals found in 1 year old needles and from accumulations from the air on needles, and bark as Dr. Waring describes in his Forest Ecosystems (Concepts and Management).

Examination of existing soil and vegetation on the proposed site indicate that the area is adaptable to use for final treatment and disposal of adequately treated effluent. Since these soils are deficient in desirable nutrients, water and minerals from the effluent may also enhance the rate of tree growth. Soil depth, ground cover, and fine texture of the soil will aid in storing water allowing filtration until evaporated, transpired and/or drained from the application site.

There is one plant, cluster elkweed (*Frasera fastigiated*) that may aid in judging when the soil temperatures are adequate for tree growth and that the vegetation is transpiring. This plant is found in limited areas of North Idaho, and the Blue Mountains of Oregon and Washington. It is abundant over much of this site.

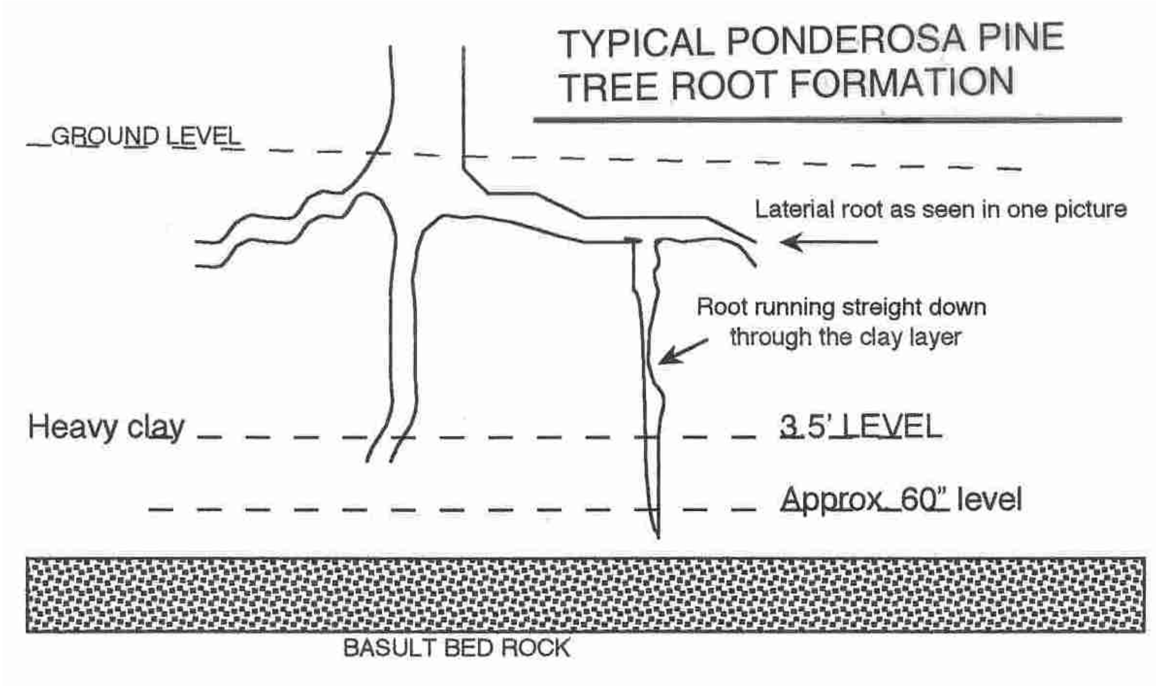
SOIL EVALUATION

Soil pits were hand dug to obtain samples for mineral testing, to verify classification, to determine depth of Ponderosa pine tree root growth, and extent of vegetation rooting.

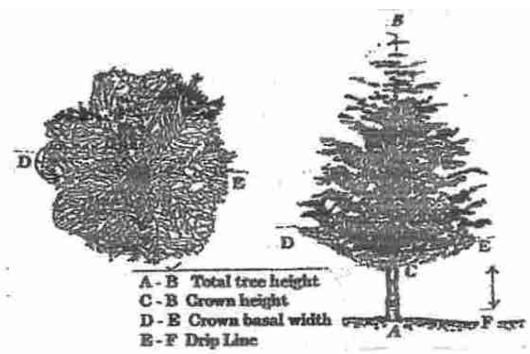
This area was included in a soil and classification survey in 1974 and a report completed in 1980. The upper slopes of this area are classified as Taney Silt Loam. Soil profiles in the proposed area meet the characteristics for this soil classification. Taney soils are very deep (60 inches and more) and moderately well drained. Past volcanic ash deposits have modified the normal effect of clay found in loam. Soil profiles in the Taney soils show very clearly that concentrated clay deposits are found at depths of 3 to 3.5 feet. Ponderosa pine root systems are penetrating the clay layers and utilizing water and nutrients found below the perched water table. It appears Ponderosa pine root systems are growing to a depth of at least 60 inches. Fractured basalt parent material lies below this depth. Vegetation normally found growing in wet soil areas are occasionally found through out the area, particularly in the water-ways apparently as a result of the perched water table, however, the Taney soils have adequate depth, holding capacity, and drainage to prevent surface water development. Areas with high percentage slopes are susceptible to surface water run-off. However, the relatively thick (½ to 1 inch) duff layer over most of the subject areas proved adequate protection to prevent accelerated erosion.

There are areas of Moctileme silt loam running through and adjacent to the proposed area. The Moctileme soils are found in the drainage ways. These soils have slow permeability, a shallow perched water table (18 to 30 inches) where there is an accumulation of clay, poorly drained, and a seasonal high water table. The vegetation growing in these areas during the spring indicate the water table may be less then the 18 inches. Cluster elkweed is more abundant in these drainage ways. The gradient within these drainage-ways prevent the accumulation of surface water except for the occasional flat areas. The flat gradient areas may accumulate water for a short time.

SOIL PROFILE				
Depth	**1974 Soil survey pH**	**On site measurements pH**	**Nitrogen**	**Phosphorus**
Duff layer		5.6	Adequate	Adequate
0 - 2 inches	6.0	6.8 – 7.0		
2 - 9 inches	5.6			
9 - 13 inches	5.8			
13 - 18 inches	5.8			
18 - 25 inches	5.7	6.8 – 7.0	Deficient	Surplus
25 - 28 inches	5.8			
28 - 36 inches	5.1			
36 - 45 inches	5.4	7.0	Deficient	Deficient
45 - 53 inches	5.7			
53 - 60 inches	6.0			



FOREST STAND EVALUATION



A variable plot cruise using a 10 basal area factor (BAF) was conducted within the Ponderosa pine plantation using a Spiegle Relaskop. The variable plot cruise provided field data for compiling a statistical estimate of merchantable tree volume and tree count per acre. The following summarizes the variable plot cruise data:

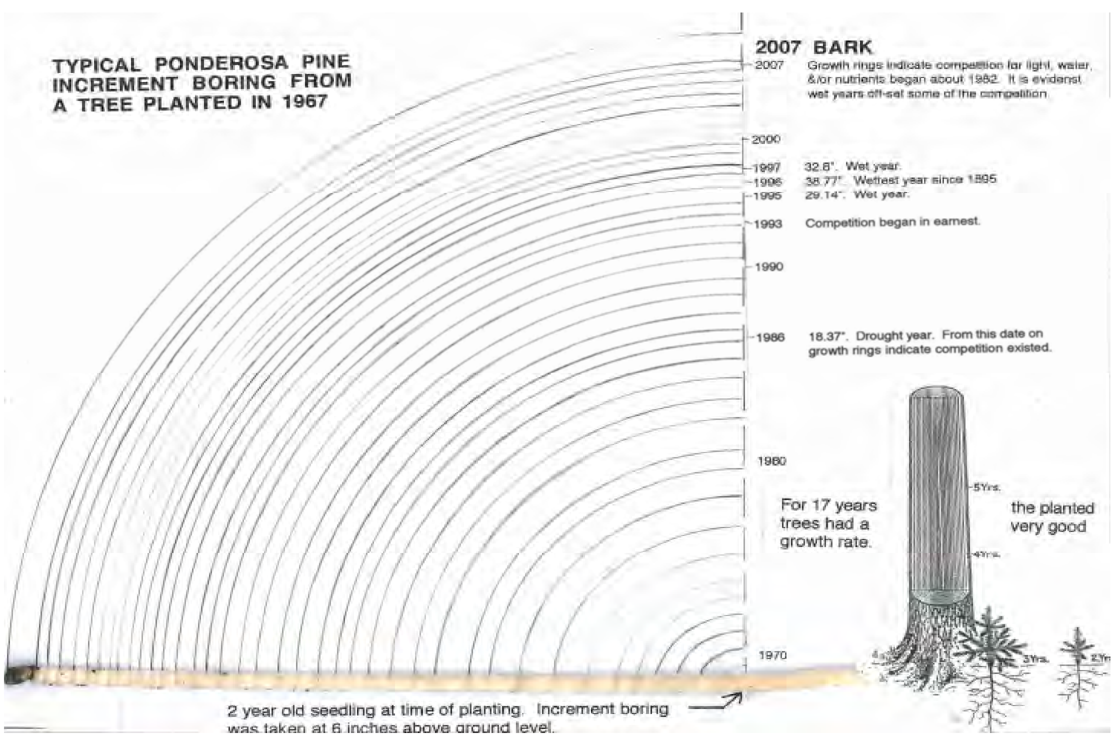
	CENTRAL AREA	
Tree Species	Average Trees per Acre	Average Merchantable Volume per Acre (mbf)
Ponderosa pine	74	3.7
Douglas fir	1	0.1
Total	75	3.8
	WEST AREA	
Ponderosa pine	99	2.3
Douglas fir	18	0.4
Total	117	2.7

NORTH STRIP		
Ponderosa pine	245	12.0
Douglas fir	64	0.2
Total	309	12.2
NOTE: Tree count rounded to nearest whole number and volume figures rounded to nearest tenth. The untreated areas between the central and west areas and along the east side were not included in the timber cruise. However, the stand characteristics should be similar to the north area. Douglas fir, Ponderosa pine, and lodge pole pine were the only conifer trees found on site.		

The resulting estimate of trees per acre derived from the variable plot cruise is lower then anticipated. A check cruise was conducted to determine validity of the variable plot cruise. Four tenth-acre plots within the central unit were used for the check cruise. Additional measurements on tree spacing were also done to determine cause of the tree count being lower then anticipated. The tree count on the fixed plots averaged from 60 on the east side to 110 within the middle areas. Distance between residual trees ranged from 21 foot to over 37 foot. The planted rows ran from 15 foot to 20 foot. Indications are that the original planting was based on 10 foot spacing within the rows that were 15 foot to 20 foot apart.

The check cruise and residual tree spacing measurements confirm that the variable plot cruise is very representative of these sites. Therefore, the variable plot cruise data is considered valid for this report.

Increment borings were made to determine growth rate and age.



A more detailed picture and drawing of an increment boring is included in the appendix displaying age, wet and drought years. The wet and drought years were confirmed by Cliff Harris, Coeur d'Alene Climatologist.

Inventoried trees were measured for total height, crown length, crown diameter, and number of merchantable logs. Tree crown diameters and crown heights were measured to determine tree crown volume. Three separate timber cruises were conducted due to existing differences in timber and understory vegetation. These areas are identified as the east area, west area, and the north strip. The understory vegetation in the treated areas was inventoried by a random sample using a square foot hoop used in range management inventory. Tables in the appendix provide cruise summaries, and tree crown volumes. The understory vegetation includes the following:

> Ninebark, snowberry, ocean spray, Oregon grape, bitter cherry, bracken fern, wild rose, wild peony, mountain bell, pine reedgrass, elk sedge, cinquefoil lupine, spirea Idaho fescue, bromegrass, ryegrass, clustered elkweed, and many various annuals.
> Three noxious weeds species were evident in the barrow pit areas, goat weed, spotted knapweed, and Canada thistle.

REVIEW OF FOREST WATER FLOW CHARACTERISTICS FOR THIS PROJECT

There are five climatic variables that are important in considering potential use of this area for treatment of waste water. These are precipitation; temperature; humidity; solar radiation; and wind. Each can have an impact on water flow characteristics within the proposed project area.

1. Precipitation - The average rain fall April 1 through June 30 is 2.13 inches. April average is 2.18 inches. However, each month has historically exceeded the average by nearly 1 inch.
2. Temperature - Nightly freezing conditions occur in April that causes the average minimum temperature of 32.6 ^{o}F. April average maximum temperature is 58.4^{o}F. May minimum average is 40.0^{o}F and high average is 69.1^{o}F. Often nightly freezing temperatures occur in early May. June has an average minimum temperature of 61.2^{o}F. and a maximum of 86.4^{o}F. June is considered a frost free month. Often maximum temperatures in these months reach 80 to 90^{o}F. July through the first week of September are relatively warm months. Average high temperatures exceed 85^{o}F. and minimum average exceeds 66^{o}F. Temperatures often exceed 95^{o}F.
3. Humidity - Plants generally respond to low humidity and high temperatures by closing stomata thus reducing transpiration. Vegetation in shaded areas, including tree crowns that are shaded tend to maintain their stomata open equal to the degree as affected by humidity and temperature. It has been found that as predawn water potentials decrease, young Douglas fir seedlings close stomata more at a given water vapor deficit (reduction in humidity). This indicates that during the hot, dry summer months the soils must be able to store water until such time as the vegetation (in this case, trees and understory vegetation) have favorable conditions for transpiring water and use of other means of disposal such as evaporation and drainage.
4. Solar radiation - evaporation from leaf surfaces, bark, and duff layers can increase atmospheric removal of moisture by as much as 30 percent of the applied water. Mist resulting from spraying water through the air results in vaporization.
5. Wind - Air movement through the tree canopy can remove vaporized moisture from the area and aid in transpiration of water through the trees. However, hot wind can dry the

air to the point stomata close terminating transpiration. Wind can accelerate evaporation of moisture deposited on vegetation resulting in lower air temperatures favorable for air transpiration.

There is one additional characteristic of vegetation to be considered in projects of this type. Most plants require a minimum level of light to induce stomata opening. This level matches the compensation point for uptake of carbon dioxide (Mansfield et al., 1981 Chapter 2). Stomata usually are wide open between light levels equivalent to 5 - 20% of full sunlight. Stomata of shade-tolerant species, such as understory vegetation, open at lower light levels. These differences can also be seen on north sides of trees. The stomata on the north side (shaded areas) of some trees require less sun light to open than those on the south side.

Both evaporation and transpiration (the evaporation of water from plants through the epidermis of the leaf and transpiration commonly controlled by the opening and closing of the leaf stomata) occurs within forest stands and the combined effect is referred to as evapotranspiration. A study of evapotranspiration rates found that in a coniferous forest, about 30% of the precipitation was accounted for by evaporation and about 70% by transpiration of the trees. The majority of evaporation occurs in the tree canopy with only a $1/10^{th}$ or less being accounted for by soil evaporation under the canopy. Soil evaporation losses within timber stands are confined to the duff and surface layer of the root zone. Generally this zone is very shallow, particularly within this project area due to very well developed duff layer which insulates the underlying soil. However, the understory vegetation functions much as the over story trees. There is an average of 6 stems per square foot of various plants occupying the understory. This vegetation occupies nearly 100 percent of the space over most of the area. Refer to page 4, Forest Stand Evaluation for a list of understory vegetation.

Complex modeling equations have been developed by forest researchers to simulate forest stand transpiration flow rates. These models involve careful measurement of site characteristics including air temperature and relative humidity, stomata conductance for a given tree species, soil water potential, tree leaf area index, and several constants associated with site physical parameters.

Bioremediation: The use of trees to treat wastewater has been studied in several agro forestry application areas in the United States, Australia, Europe, China, Near East Peru, South Africa, Mexico, and India. One example actually dates back to 1911 when a tree plantation near Cairo was used to dispose of the city's sewage water. This area was converted to production of citrus, cereal, and vegetable crops in the mid-1980's and recently increased to over 3,000 acres (1,260 hectare). Some communities in Egypt are using sewage or drainage water after primary treatment to irrigate woodlots that include Eucalyptus, Tamarix, and Casuarina species. It is well documented that cottonwoods and related species are uniquely suited for use in bioremediation because of their ability to uptake heavy metals dissolved in water from waste water treatment plants. These deciduous trees apparently are unique in their ability to sequester these metal salts. There is no evidence that conifers have any ability to uptake heavy metal salts. However, experiments are being carried out and an increased interest in use of native conifers for treatment of waste water. So far there appears to be no example of deliberate use of waste waster for production of timber resources in the United States.

GENERAL FOREST STAND CHARACTERISTICS

1. The rate of transpiration for conifer species is directly related to the canopy leaf area and site characteristics.

2. For conifer species, the rate of sapwood flow is determined by the area of active sapwood and its permeability. Different species have been found to have differing wood permeability. The amount of active sapwood is directly proportional to the amount of canopy leaf area so the uptake of water by the trees can be predicted by knowing either; 1) the sapwood area and wood permeability; or 2) by estimation of the canopy leaf area. The canopy leaf area is used to estimate the capacity for this project by use of the estimated crown volume by measurements for crown basal area and crown height of sampled trees.

3. Conifers respond most directly to water availability by modifying their canopy leaf area. A study of controlling ground vegetation within forest stands in dry areas found that tree leaf area was the most responsive of the tree characteristic to site improvement. The immediate response was that leaf area increased followed by increases in tree size.

4. Forest stands can loose water by three separate means; 1) evaporation from moist surfaces; 2) transpiration losses through the tree leaves; and 3) by soil drainage. These are impacted by site conditions including precipitation patterns, forest tree species, soil types and texture, and site temperatures and humidity. Evidence from irrigated sites suggests that when water is freely available, evapotranspiration rates can be as much as 5-6mm/ac/day.

5. Young fast growing conifer trees have wide sapwood zones that are capable of transmitting large volumes of water and nutrient up and down the tree trunk. As trees grow larger, diameter and height, the ability to conduct water through sapwood decreases and eventually limit height growth. Thus, as trees mature, all growth characteristics become less (needles are shorter, crown less in size, sapwood narrower, growth rings have less width, and less height growth.).

SITE CHARACTERISTICS

1. Evaluation of the tree canopies within the proposed Heyburn project area found that the canopy basal area occupies 33% of the area in the West Area, 25% in the Central Area, and 93% in the north strip. However, understory vegetation occupies most of the forest floor. The well developed duff layer provides soil protection, increased water absorption, and insulation.

The tree canopy basal area on the north strip is near the total surface area. This is evident by the size and type of understory vegetation. The few understory plants are tall and leaning towards areas of sunlight. Bitter cherry and Ocean spray are the predominant plants. There is a small area of dead timber in the north unit that may need treatment to control bark beetles.

2. Based upon average site precipitation for the months of June, July, August, and September this site averages about .76 mm/day of precipitation when evaporation losses are

considered from the stand canopy (approximately 30% loss of precipitation). However, the trees will transpire about 3-5 mm/day which means that trees must draw on reserves stored in sapwood, or deplete soil reserves through internal stress within the tree.

3. Using the .76 mm precipitation per day average, and an estimated transpiration demand of 4mm/ac/day for the existing trees they can utilize an additional 3.24mm/ac/day when the water is applied at the ground surface which works out to approximately 3,460 gallons/ac/day. If the waste water were applied to the canopy to utilize the evaporation potential the application rate could be increased by 30%. This would bring the total irrigation potential per acre to approximately 4,500 gallons/acre/day . Therefore, the anticipated disposal need rate of 120 gallons per minute or 86,400 gallons per 12 hour day would require 19 acres for treatment. This does not include the evapotranspiration rate that the understory vegetation can contribute to the total capacity.

4. A unique plant, cluster elkweed, (F*rasera fastigiated),* is found on this site that occurs in only a few areas; northern Idaho, and the Blue Mountains of Oregon and Washington. It appears this plant could be used as an indicator plant to determine when the soil temperature is right for trees to begin transpiration of water. This year it appeared about the first of May. Further observation is necessary to confirm this observation.

SUMMARY

The proposal to apply waste water appears to be a feasible means to disperse approximately 86,400 gallons per 12-hour day, (120 gal. per minute for 12-hour day, Engineer's estimate) of treated effluent. A minimum of 19 acres will be required to treat this amount of effluent. Based on literature review and an inventory of the trees on the project area, it is concluded that on non-rainy days the existing trees and vegetation will transpire at least 70% of the applied effluent. If the effluent is caused to spray into the tree canopies an additional 20 to 30% will be disposed of by increased evaporation from the tree crowns, branches, and stems. Remaining effluent will drain into the soils to be utilized by vegetation down slope from the project area. As the forest adjusts to the changed environment, the transpiration rate will increase and less will be available to drain into the sub-soils. The expected changes in the forest include the following:

1. Vegetation less tolerant to wet soil conditions will be replaced by those that thrive best. Ninebark will likely be the first to go. Ponderosa pine with the deep root systems will continue to thrive. It is anticipated that Douglas fir and grand fir will seed in from adjacent areas.

2. As the overstory tree crowns expand the understory vegetation will decrease for lack of sunlight or displaced by more shade tolerant species.

3. The sapwood on all tree species will increase in thickness. This will aid in increasing the transpiration of water. Tree crowns will enlarge in width and depth. Both diameter and height of trees will increase in proportion to the rate of water application. Tree root systems will become shallower and trees may become more subject to wind throw.

4. Vegetation that prefers dry sites will be displaced.

5. Root rot and other fungi may increase; over time this may become a problem maintaining a stable stand of timber. Douglas fir is the most susceptible species to this condition.

RESULTS OF LITERATURE REVIEW

During the literature review it became apparent that considerable research has been accomplished on transpiration rates for conifer seedlings, but, a limited amount on older timber. A report in the *Ecology* publication, Vo. 62, no. 3, pages 717-726, (by Knight, Fahey, Running, Harrison, and Wallace) states that "tree photometers were used to estimate transpiration from two contrasting stands of 100 year old lodge pole pine (8" to 10" dbh). The maximum observed average hourly uptake was 2.5 to 3.5 liters (.66 to .92 gal.) per tree. On overcast days this reduced by 30 to 40 percent and near zero during rainy periods.

The Forester's handbook has a section on transpiration. It states "Experimental cutting of all vegetation on a 33 acre watershed in the mountains of North Carolina almost completely eliminated transpiration and increased runoff the first year by 17 inches.. In general, transpiration from brush and forest-covered watersheds is probably 5 to 25 inches., with a possible maximum, in dense stands, of 35 inches."

The Forester's handbook also reports that studies along the Gila River in Arizona determined that vegetation was using the equivalent of 20 to 43 inches of annual rain fall which was two to three times the actual precipitation. This research determined that the stream side vegetation was using a large portion of the stream flow. This supports a theory that trees will seek and utilize what ever water is available up to the limits of the trees ability.

On a similar project to this one, Dr. Richard Waring, Oregon State University, advised that accurate estimates of leaf area index was not needed for the stand of timber within the project area because the area averages above 5 square millimeters of projected leaf area per square millimeter of ground area. The ground area is considered here as that area within what is known as the drip line of the tree crown. Dr. Waring also estimated that the expected transpiration rates would average between 3 to 4 millimeters per day per tree under present stand conditions during the months of June and July. Normally the transpiration rates drop during August due to reduction of available water. If water is applied the transpiration rate should continue through the application period or a change in weather (air temperature, wind, length of day light, etc.). Trees on the Heyburn project are younger, have near equal crown basal area, and crown volume. However, it is anticipated that existing understory vegetation (broadleaf plants) can supplement transpiration rates until tree crowns develop to increase transpiration rates.

Results of research work at the Priest Lake Experimental Forest support this estimate. Measurements of transpiration rates of dense mixed conifer forests (cedar, hemlock, white pine, western larch, etc.) at the Priest River Experimental Forest (P.R.E.F.) determined the average transpiration rate to be 3mm/ac./day for timber within the study area. The P.L.E.F. trees are much older, taller, and larger in diameter then the Heyburn project sites. The Heyburn trees also have much thicker sapwood then the P.L.E.F. trees. This is likely caused by the larger trees on the P.L.E.F. attempt to compensate for increased hydraulic resistance resulting from the greater tree height. This also reduces leaf area. The two conditions results in reduced transpiration. This theory is supported by research conducted in 1998 by the Oregon State University, Woods Hole Marine Biological Laboratory, and the U.S. Forest Service within the Wind River Basin and other such studies.

The Wind River study also found that older trees had much lower leaf area per unit of sapwood area compared with younger trees and that soil moisture became more depleted in younger stands compared with old-growth areas.

The rate of transpiration is directly related to canopy leaf area. The amount of water and dissolved elements carried to the leaf area is determined by the sapwood (growing portion of the stem) area through the tracheids. The amount of active sapwood is directly proportional to the amount of canopy leaf area so the uptake of the trees is directly predicted by knowing either sapwood area or estimated canopy leaf area. Conifers respond to water availability by modifying canopy leaf area.[1][1] Otherwise, one can expect the most visible and immediate change in the rate of growth by conifers will be in the color, needle length, numbers of needles per stem, thickness of phloem and xylem (sapwood), and visible density. This will be followed by increased height and diameter growth. So far there is no known evidence from research that conifers are capable of increasing metal uptake from added effluent. However, Martin, Leonard & Stamp reported in 1976 that "water is absorbed at the roots by osmosis, and any dissolved mineral nutrients travel with it through the xylem. A fully grown tree may lose several hundred gallons of water through its leaves on a hot, dry day. About 90% of the water that enters a plant's roots is used for this process. The transpiration ratio is the mass of water transpired compared to the mass of dry matter produced. The transpiration of crops tends to fall between 200 and 1,000. Otherwise, for every 200 to 1,000 pounds of dry wood and needle weight produced by a tree an equal amount of water is transpired less about 10 percent". The 10 percent is used in photosynthesis. If not

[1]Information gained from studies conducted at Pringle Falls in Oregon where the effect of ground vegetation on tree growth and canopy leaf area was monitored.

utilized by the tree in production of wood fiber, the metals could be deposited in the wood cells as they develop. I have not found research that supports the theory that conifer trees take up any dissolved minerals and metals; however minerals are used in the photosynthesis process for production of needles, wood fiber, and CO_2.

Research has found that high rates of nitrogen application during normal hardening-off periods have resulted in winter kill. Apparently the abnormal application of water combined with the increased nitrogen causes the sapwood to be expanded with excessive water that results in freezing and damage to the living cells.

Due to growth characteristics of conifer trees, needles will become longer, larger in diameter, more abundant, and xylem and phloem (sapwood) will become thicker. This will result in greater demand for water as the trees adapt to the change in available water and possibly increased nutrients.

Conifers have higher leaf areas than hardwoods by a factor of about 3. The conifer transpiration rates are lower then hardwoods (Douglas and Swank 1975). Conifer trees (except western larch) may continue transpiration long after hardwood trees shed their leaves and begin as soon as soil and air temperatures induce osmosis and transpiration .

Studies have found that clear cutting of trees results in an increase of 40 to 50 percent in water yield. This would indicate that trees remove 40 to 50 percent of the natural applied water through evapotranspiration. The remaining water is tied up in the soils, duff, utilized by understory vegetation, drained into the subsoil, and/or evaporates. However, under natural occurring conditions, as the available water supply decreases (drying conditions) and the hydrostatic (water pressure) increases to the limit of the tree needle stomata the water flow reduces and the production of summer wood begins. The stomata may close completely to conserve water within the tree. The summer wood is the darker area of the annual growth ring. Conifer trees that receive abundant water through out the growing season have wide spring wood (light colored area of the growth ring) and little to no summer wood. This condition can be seen in cemeteries and lawn areas.

Nutrient storage in roots, particularly fine roots, can be extensive. The growth of many forests is limited by nutrient, because most of the nutrient pool is in organic matter and not available. A large portion of the nutrient content of the forest floor and soil organic matter may be composed of soil microbes, including mycorrhizal fungi. The most apparent below ground response of plants to low nutrient concentrations is an increase in the root/shoot ratio which increases the volume of soil exploration and decreases diffusion distances, otherwise roots grow more abundant and tree crowns are reduced.

RECOMMENDATIONS

1. Many tree attacking insects and diseases are species selective (have preferred host). Three examples are: Douglas fir root rot and Douglas fir bark beetles generally attack Douglas fir. Western pine beetles attack various pine trees such as Ponderosa pine and lodgepole pine. A mixture of tree species will provide barriers to reduce spread rates and back up should occur

following application of water and elements that may be carried in the effluent. Once the project is underway it is recommended that Douglas fir, grand fir, and western larch be interplanted to provide a mix tree species that will be more adapted to the increased water supply and provide protection incase of insect or disease problems develop. If the untreated areas are included, remove the understory vegetation, except for tree species. Save as many co-dominate trees as reasonably possible. Dispose of debris shortly after cutting to prevent insect invasion.

2. Gradually reduce rate of application beginning no later than October 1, to help induce the trees hardening off process. Annual effluent application should be terminated no later than October 30. This should compensate for the effects the additional water and nitrogen can cause.

3. Maintain a tree spacing using the following rule: for overstory trees - measure the dbh of trees in inches (convert this to feet) and add 10 feet. (Example: A 12" tree would be 12' plus 10' = 22' - this tree needs an area with a 22' radius for growing space). **Caution - apply this to the overstory trees only.**

Trees in the understory should be thinned to maintain a low canopy and the crowns have growing space. The objective is to have these trees occupy a space below the spray level of the sprinklers to maximize the tree crown evaporation and keep these trees healthy.

4. When thinning to maintain the desired spacing and health, first select by apparent health condition, crown density, crown size, mechanical condition, and then tree species to maintain a mixture. The exception is all lodge pole pine should be removed when other species are present. The reason for this is that lodgepole pine does not do well in wet soils.

5. Manage for an all age and mixed species stand to provide insurance against loss. The Ponderosa pine is deep rooted and will aid in transpiring water that reaches deeper soil depths. In the long run Ponderosa pine may be replaced by trees with greater tolerance for wet soils.

6. Manage for a stand of timber that is less then 100' tall to minimize wind throw and maximize transpiration rates. The additional water will cause trees to develop shallow roots. Future trees will become more susceptible to wind throw.

7. Encourage understory vegetation that grows well on wet soils. Most of the natural occurring plants favor dryer conditions then will be found during effluent application. Willow, Mt. maple, common snowberry, rose, and myrtle pachystima are examples of plants that may become established. These plants will aid in evaporation of applied effluent. However, the priority should be to encourage conifer tree growth.

8. Begin checking out the theory that cluster elkweed can be used as an indicator plant for when to begin application of effluent. Maintain a log of dates and when the plant first appears in the spring. A picture and information about the plant is in the appendix.

9. Control noxious weeds that have invaded the area such as spotted knapweed (c*entaurea maculosa*), Canada thistle (c*irsium arvense*), and goat-weed also called St. Johns-wort (h*ypericum perforatum*). Since barrow pits are now being used as waste areas a monitoring program should be active to prevent establishment of these and other undesirable weeds. The County Extension Office may be able to help with such a program.

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Tom D. Whitson, Larry C. Burrill, Steven A. Dewey, David W. Cudney, B. E. Nelson, Richard D. Lee, Robert Parker. Weeds of the West. University of Wyoming. 1991

APPENDIX

TIMBER DESCRIPTION:

WEST AREA:

The West Area was the most recent unit to be treated by removal of the understory vegetation. Small diameter D. F. has been removed . There is an average of 99 P.P. and 18 D. F. trees per acre in this area. L.P. and mature P.P. were seen, during the timber cruise, but, they did not appear in the sample plots. Therefore, non were included in the inventory. The residual trees have well developed crowns with good color. The D.F. crowns are much fuller , longer, and wider than P.P. There is no apparent insect or disease problems. The estimated merchantable volume for this area is 2.3 MBF P.P. and 0.4 MBF D.F.. There is an average of 99 P.P. and 18 D. F. trees per acre in this area. L.P. and mature P.P. were seen, during the timber cruise, but, they did not appear in the sample plots. Therefore, are not included in the inventory. The residual trees have well developed crowns with good color. There is no evidence of insect or disease problems. The understory treatment included plants such as ocean spray, ninebark, snowberry, and bitter-cherry . These plants have re-sprouted over most of the area. They are now about 6 inches in height and sparse. compared to the Central area. Pine grass is the dominate plant. Oregon grape has reestablished in the areas where the clearing debris was burned.

The following tables provide results of the timber cruise for the West Area:

PONDEROSA PINE TREE CROWN AND WOOD VOLUME (per acre)
WEST AREA

TREE SPECIES	D.B.H.	AVG./ACRE TREES	AVG./ACRE VOL.	AVERAGE CROWN BASAL AREA/TREE	AVERAGE CROWN HEIGHT/TREE	AVERAGE CROWN VOLUME/TREE	TOTAL CROWN VOLUME/ACRE
P.P.	6"	41	0	78 sq. ft.	15 ft.	566 cu. ft.	23,565 cu. ft.
	8"	11	0	113 sq. ft.	17 ft.	960 cu. ft.	10,560 cu. ft.
	10"	4	.10	154 sq. ft.	30 ft.	2,310 cu. ft.	9,240 cu. ft.
	11"	21	.70	154 sq. ft.	26 ft.	2,002 cu. ft.	42,042 cu. ft.
	12"	10	.42	137 sq. ft.	27 ft.	1,850 cu. ft.	18,750 cu. ft.
	13"	4	.22	133 sq. ft.	39 ft.	2,594 cu. ft.	31,620 cu. ft.
	14"	4	.26	227 sq. ft.	31 ft.	3,518 cu. ft.	14,072 cu. ft.
	16"	4	.62	170 sq. ft.	47 ft.	3,995 cu. ft.	15,980 cu. ft.
TOTAL TREES/AC.		99					
TOTAL VOL. (mbf)/AC.			2.33	TOTAL AVG. P.P. CROWN VOLUME/ACRE FOR CENTRAL AREA			165,849 cu. ft.

NOTE: Ponderosa pine trees have very well developed crowns in this unit.
Average Volume per acre is Thousand board foot (mbf).
Total crown basal area per acre = 11,781 sq. ft..

DOUGLAS FIR TREE CROWN AND WOOD VOLUME (per acre)
WEST AREA

TREE SPECIES	D.B.H.	AVG./ACRE TREES	AVG./ACRE VOL.	AVERAGE CROWN BASAL AREA/TREE	AVERAGE CROWN HEIGHT/TREE	AVERAGE CROWN VOLUME/TREE	TOTAL CROWN VOLUME/ACRE
D.F.	6"	10	0	50 sq. ft.	10 ft.	250 cu. ft.	2,500 cu. ft.
	11"	3	.1	254 sq. ft.	36 ft.	4,572 cu. ft.	13,716 cu. ft.
	12"	3	.1	254 sq. ft.	40 ft.	5,080 cu. ft.	15,240 cu. ft.
	15"	2	.2	314 sq. ft.	48 ft.	7,536 cu. ft.	15,072 cu. ft.
TOTAL TREES/AC.		18					
TOTAL VOL. (mbf)/AC.			0.4	TOTAL AVG. D.F.. CROWN VOLUME/ACRE FOR CENTRAL AREA			16,528 cu. ft.

NOTE: The few Douglas fir trees ocurring in this unit have very well developed crowns.
D.F. occurs mostly in the south central part of the unit.
Average Volume per acre is thousand board foot (mbf).
Total crown basal area per acre = 2,652 sq. ft..

Timber Inventory
Heyburn - west area
Treated area

SAWTIMBER
Thousand Board Feet (MBF) -- Scribner Log Rule

SPECIES	8	9	10	11	12	13	14	15	16	17	18+	TOTALS	PER AC
	DBH												
Ponderosa pine	.0	.0	.5	3.5	2.1	1.1	1.3	.0	3.1	.0	.0	11.6	2.320
Douglas fir	.0	.0	.0	.5	.5	.0	.0	.8	.0	.0	.0	1.8	.360
TOTALS	.0	.0	.5	4.0	2.6	1.1	1.3	.8	3.1	.0	.0	13.4	2.680

SAWTIMBER
Numbers of Trees

SPECIES	8	9	10	11	12	13	14	15	16	17	18+	TOTALS	PER AC
	DBH												
Ponderosa pine	0	0	18	106	51	22	19	0	21	0	0	237	47.400
Douglas fir	0	0	0	15	13	0	0	8	0	0	0	36	7.200
TOTALS	0	0	18	121	64	22	19	8	21	0	0	273	54.600

5/27/08

PULPWOOD
Cunits (100 Cu Ft)

SPECIES	0	1	2	3	4	5	6	7	8	9	10+	TOTALS	PER AC
	DBH												
Ponderosa pine	0	0	0	0	0	0	4	0	2	0	0	6	1.200
Douglas fir	0	0	0	0	0	0	1	0	0	0	0	1	.200
TOTALS	0	0	0	0	0	0	5	0	2	0	0	7	1.400

PRE-MERCHANTABLE & PULPWOOD
Numbers of Trees

SPECIES	0	1	2	3	4	5	6	7	8	9	10+	TOTALS	PER AC
	DBH												
Ponderosa pine	0	0	0	0	0	0	204	0	57	0	0	261	52.200
Douglas fir	0	0	0	0	0	0	51	0	0	0	0	51	10.200
TOTALS	0	0	0	0	0	0	255	0	57	0	0	312	62.400

5/27/08

Idaho Panhandle Forestry
Forestry Consultant
Post Falls, Idaho

Table 1

NORTH STRIP

The understory in this area has not been treated. Based on the timber cruise there is an average of 245 P.P. and 64 D.F. trees per acre in this area. The average merchantable volume per acre is 10.4 MBF. Crown density is much greater. The average tree crown basal area is about 40,000 sq. ft. per acre. This indicates the tree crowns have near full closure on the area. The existing understory vegetation is more sparse and taller. The height growth of understory vegetation is caused by the plants growing towards sunlight and competition. There are also more D.F. trees in the understory. There is an average of 147 trees in the understory that are 6 to 8 inches in diameter. Tree seedlings were not evident in the area. This indicates there is inadequate sunlight for regeneration. Ocean spray and bitter-cherry are the main understory species. s nearly equal to the 43,560 sq. ft. per areaExcept for about 1 acre, the tree crown basal area is near equal to the square footage per acre

The following tables provide results of the timber cruise for the North Strip: The narrow leave strip between the West Area and the Central Area is comparable to the North Strip. Therefore: the per acre data can be used to estimate impact on that area.

PONDEROSA PINE TREE CROWN AND WOOD VOLUME (per acre)
NORTH STRIP

TREE SPECIES	D.B.H.	AVG./ACRE TREES	VOL.	AVERAGE CROWN BASAL AREA/TREE	AVERAGE CROWN HEIGHT/ TREE	AVERAGE CROWN VOLUME/TREE	TOTAL CROWN VOLUME/ACRE
P.P.	6"	41	0	84 sq. ft.	13 ft.	416 cu. ft.	17,056 cu. ft.
	8"	46	0	113 sq. ft.	17 ft.	960 cu. ft.	44,160 cu. ft.
	10"	33	.7	154sq. ft.	30 ft.	2,310 cu. ft.	76,230 cu. ft.
	11"	3	.1	158 sq. ft.	26 ft.	2,054 cu. ft.	6,162 cu. ft.
	12"	34	1.9	137 sq. ft.	27 ft.	1,850 cu. ft.	62,900 cu. ft.
	13"	39	3.2	133 sq. ft.	38 ft.	2,527 cu. ft.	98,553 cu. ft.
	14"	26	2.6	227 sq. ft.	31 ft.	3,516 cu. ft.	91,466 cu. ft.
	15"	7	.8	242 sq. ft.	41 ft.	4,961 cu. ft.	34,727 cu. ft.
	16"	11	1.8	181sq. ft.	37 ft.	3,348 cu. ft.	36,828 cu. ft.
	17"	5	1.0	305 sq. ft.	38 ft.	5,795 cu. ft.	28,975 cu. ft.
TOTAL TREES/AC.		245					
TOTAL VOL. (mbf)/AC.			10.2	TOTAL AVG. P.P. CROWN VOLUME/ACRE FOR CENTRAL AREA			497,059 cu. ft.

NOTE: Ponderosa pine trees have very well developed crowns in this unit.
Average Volume per acre is Thousand board foot (mbf).
Total crown basal area per acre = 34,335 sq. ft..

DOUGLAS FIR TREE CROWN AND WOOD VOLUME (per acre)
NORTH STRIP

TREE SPECIES	D.B.H.	AVG./ACRE TREES	VOL.	AVERAGE CROWN BASAL AREA/TREE	AVERAGE CROWN HEIGHT/ TREE	AVERAGE CROWN VOLUME/TREE	TOTAL CROWN VOLUME/ACRE
D.F.	6"	61	0	78 sq. ft.	15 ft.	585 cu. ft.	35,685 cu. ft.
	8"	0	0				
	9"	0	0				
	10"	0	0				
	11"	0	0				
	12"	3	2	452 sq. ft.	40 ft.	9,040 cu. ft.	27,120 cu. ft.
TOTAL TREES/AC.		64					
TOTAL VOL. (mbf)/AC.			0.2	TOTAL AVG. D.F. CROWN VOLUME/ACRE FOR CENTRAL AREA			62,805 cu. ft.

NOTE: The occasional Douglas fir trees in this unit have very well developed crowns.
Average Volume per acre is thousand board foot (mbf).
Total crown basal area per acre = 6,114 sq. ft..

Timber inventory
Heyburn - north strip
Untreated Area

SAWTIMBER
Thousand Board Feet (MBF) -- Scribner Log Rule

SPECIES	8	9	10	11	12	13	14	15	16	17	18+	TOTALS	PER AC
	D B H												
Ponderosa pine	.0	.0	3.3	.5	9.5	15.8	13.1	4.0	8.8	4.8	.0	59.8	11.960
Douglas fir	.0	.0	.0	.0	.9	.0	.0	.0	.0	.0	.0	.9	.180
TOTALS	.0	.0	3.3	.5	10.4	15.8	13.1	4.0	8.8	4.8	.0	60.7	12.140

SAWTIMBER
Numbers of Trees

SPECIES	8	9	10	11	12	13	14	15	16	17	18+	TOTALS	PER AC
	D B H												
Ponderosa pine	0	0	128	15	166	195	131	33	57	25	0	750	150.000
Douglas fir	0	0	0	0	13	0	0	0	0	0	0	13	2.600
TOTALS	0	0	128	15	179	195	131	33	57	25	0	763	152.600

PULPWOOD
Cunits (100 Cu Ft)

SPECIES	0	1	2	3	4	5	6	7	8	9	10+	TOTALS	PER AC
	D B H												
Ponderosa pine	0	0	0	0	0	0	4	0	8	0	2	14	2.800
Douglas fir	0	0	0	0	0	0	6	0	0	0	0	6	1.200
TOTALS	0	0	0	0	0	0	10	0	8	0	2	20	4.000

PRE-MERCHANTABLE & PULPWOOD
Numbers of Trees

SPECIES	0	1	2	3	4	5	6	7	8	9	10+	TOTALS	PER AC
	D B H												
Ponderosa pine	0	0	0	0	0	0	204	0	229	0	37	470	94.000
Douglas fir	0	0	0	0	0	0	306	0	0	0	0	306	61.200
TOTALS	0	0	0	0	0	0	510	0	229	0	37	776	155.200

5/27/08

Idaho Panhandle Forestry
Forestry Consultant
Post Falls, Idaho

Table 2

CENTRAL AREA

The Central Area was the first unit treated by cutting the understory vegetation. There is an average of 74 P.P. and 13 D.F. residual trees per acre. The average spacing is about 22 feet by 22 feet. There area areas where the spacing is greater as found on the east side. Most of the D.F. is found in the south central area of this unit. The residual trees have full crowns, appear healthy, and well adapted to this site. The present stocking level is near recommended spacing for mature stands of timber. Crown density (basal area) averages 11,000 sq. ft. per acre. This shows that the tree crown basal area is occupying only 25 percent of the site. This low crown density is reflected in the density of the understory vegetation. It appears the understory vegetation sprouting following cutting was rapid and is now about 18 to 24 inches in height. There is an average of 12 stems of mostly snowberry and ninebark growing in the area.

The following tables provide results of the timber cruise for the Central Area.

PONDEROSA PINE TREE CROWN AND WOOD VOLUME (per acre)
CENTRAL AREA

TREE SPECIES	D.B.H.	AVG./ACRE TREES	AVG./ACRE VOL.	AVERAGE CROWN BASAL AREA/TREE	AVERAGE CROWN HEIGHT/TREE	AVERAGE CROWN VOLUME/TREE	TOTAL CROWN VOLUME/ACRE
P.P.	7"	3	0	28 sq. ft.	20 ft.	283 cu. ft.	849 cu. ft.
	8"	2	0	113 sq. ft.	20 ft.	848 cu. ft.	1,696 cu. ft.
	9"	7	0	71 sq. ft.	22 ft.	781 cu. ft.	5,467 cu. ft.
	10"	14	.07	83 sq. ft.	21 ft.	871 cu. ft.	12,194 cu. ft.
	11"	2	.06	113 sq. ft.	26 ft.	1,469 cu. ft.	2,938 cu. ft.
	12"	10	.45	141 sq. ft.	29 ft.	1,833 cu. ft.	18,330 cu. ft.
	13"	12	.75	155 sq. ft.	34 ft.	2,635 cu. ft.	31,620 cu. ft.
	14"	9	.69	177 sq. ft.	35 ft.	3,098 cu. ft.	27,882 cu. ft.
	15"	8	.82	242 sq. ft.	41 ft.	4,961 cu. ft.	39,688 cu. ft.
	16"	3	.33	181 sq. ft.	37 ft.	3,348 cu. ft.	10,044 cu. ft.
	17"	3	.54	305 sq. ft.	38 ft.	5,795 cu. ft.	17,385 cu. ft.
	18"	1	.15	416 sq. ft.	46 ft.	9,568 cu. ft.	9,568 cu. ft.
TOTAL TREES/AC.		74					
TOTAL VOL. (mbf)/AC.			3.68	TOTAL AVG. P.P. CROWN VOLUME/ACRE FOR CENTRAL AREA			177,661 cu. ft.

NOTE: Ponderosa pine trees have very well developed crowns in this unit.
Average Volume per acre is Thousand board foot (mbf).
Total crown basal area per acre = 10,868 sq. ft..

DOUGLAS FIR TREE CROWN AND WOOD VOLUME (per acre)
CENTRAL AREA

TREE SPECIES	D.B.H.	AVG./ACRE TREES	AVG./ACRE VOL.	AVERAGE CROWN BASAL AREA/TREE	AVERAGE CROWN HEIGHT/TREE	AVERAGE CROWN VOLUME/TREE	TOTAL CROWN VOLUME/ACRE
D.F.	14"	0.7	.08	113 sq. ft.	45 ft.	2,545cu. ft.	1,782 cu. ft.
	15"	0.6	.06	254 sq. ft.	50 ft.	6,350 cu. ft.	3,810 cu. ft.
	16"	0	0				
	17"	0	0				
	18"	0	0				
				367 sq. ft.			
TOTAL TREES/AC.		1.3					
TOTAL VOL. (mbf)/AC.			0.08	TOTAL AVG. D.F. CROWN VOLUME/ACRE FOR CENTRAL AREA			5,592 cu. ft.

NOTE: The few Douglas fir trees ocurring in this unit have very well developed crowns.
D.F. occurs mostly in the south central part of the unit. Appears all small diameter, codominate, have been removed.
Average Volume per acre is thousand board foot (mbf).
Total crown basal area per acre = 231 sq. ft..

Timber Inventory
Hayburn State Park #2
Waste
P.P. Plantation

SAWTIMBER
Thousand Board Feet (MBF) -- Scribner Log Rule

SPECIES	8	9	10	11	12	13	14	15	16	17	18+	TOTALS	PER AC
	DBH												
Ponderosa pine	.0	.0	1.4	1.6	8.9	15.0	12.3	15.2	6.6	10.7	3.0	74.7	3.735
Douglas fir	.0	.0	.0	.0	.0	.0	1.5	1.2	.0	.0	.0	2.7	.135
TOTALS	.0	.0	1.4	1.6	8.9	15.0	13.8	16.4	6.6	10.7	3.0	77.4	3.870

SAWTIMBER
Numbers of Trees

SPECIES	8	9	10	11	12	13	14	15	16	17	18+	TOTALS	PER AC
	DBH												
Ponderosa pine	0	0	56	47	196	250	158	138	55	68	17	985	49.250
Douglas fir	0	0	0	0	0	0	14	13	0	0	0	27	1.350
TOTALS	0	0	56	47	196	250	172	151	55	68	17	1012	50.600

PULPWOOD
Cunits (100 Cu Ft)

SPECIES	0	1	2	3	4	5	6	7	8	9	10+	TOTALS	PER AC
	DBH												
Ponderosa pine	0	0	0	0	0	0	0	2	2	8	15	27	1.350
TOTALS	0	0	0	0	0	0	0	2	2	8	15	27	1.350

PRE-MERCHANTABLE & PULPWOOD
Numbers of Trees

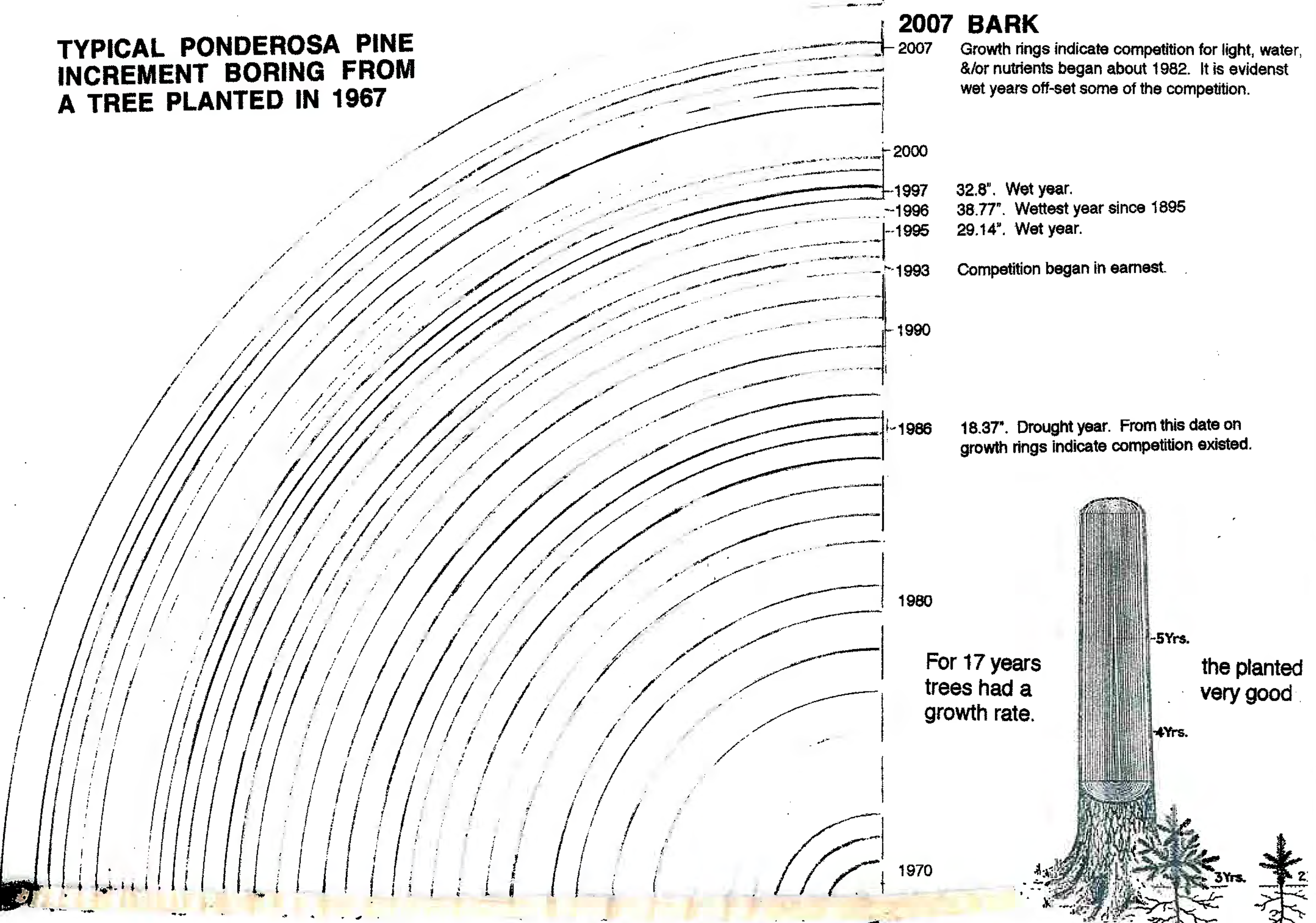
SPECIES	0	1	2	3	4	5	6	7	8	9	10+	TOTALS	PER AC
	DBH												
Ponderosa pine	0	0	0	0	0	0	0	58	44	139	223	464	23.200
TOTALS	0	0	0	0	0	0	0	58	44	139	223	464	23.200

5/18/08

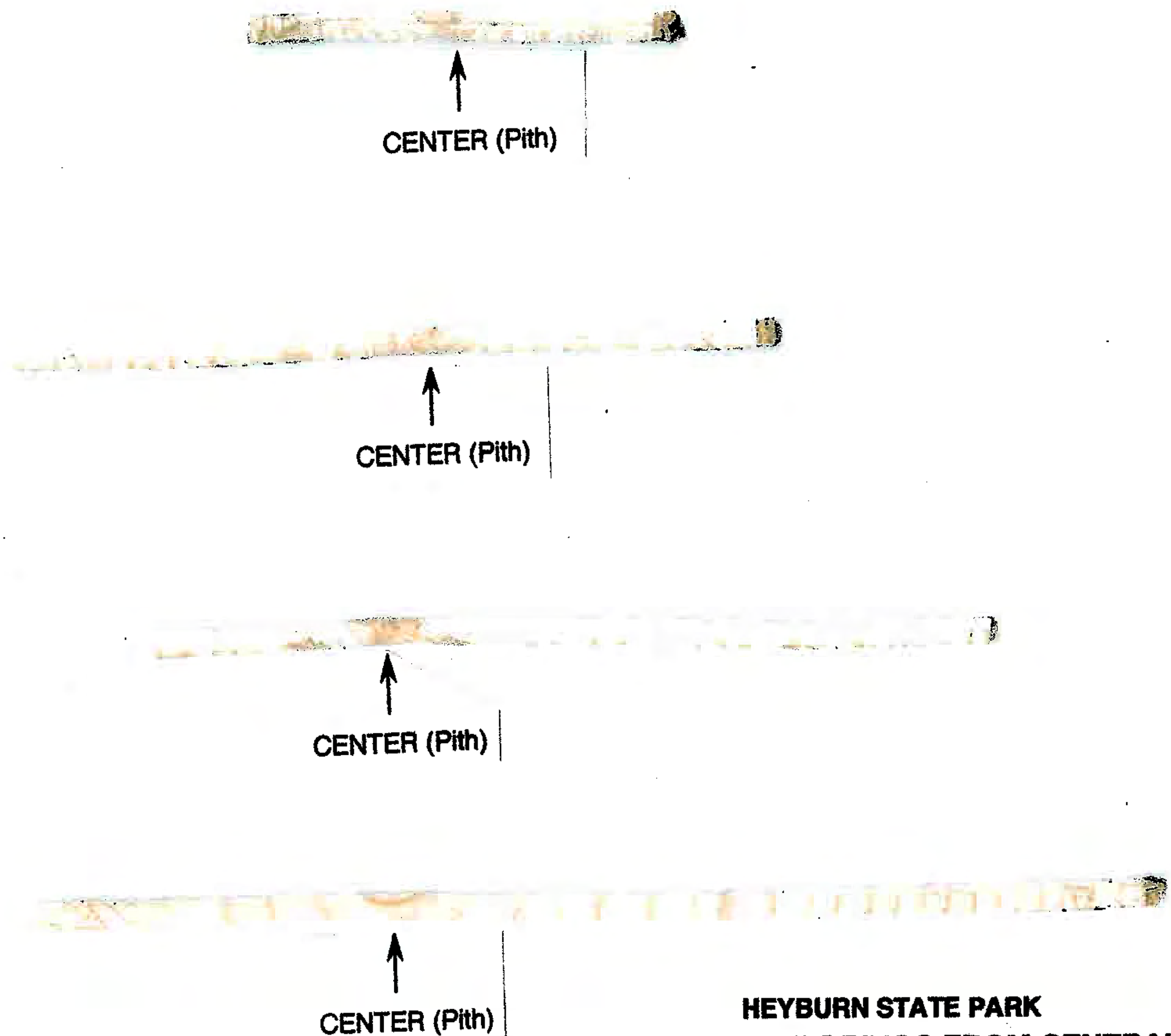
Idaho Panhandle Forestry
Forestry Consultant
Post Falls, Idaho

Table 3

TYPICAL PONDEROSA PINE INCREMENT BORING FROM A TREE PLANTED IN 1967

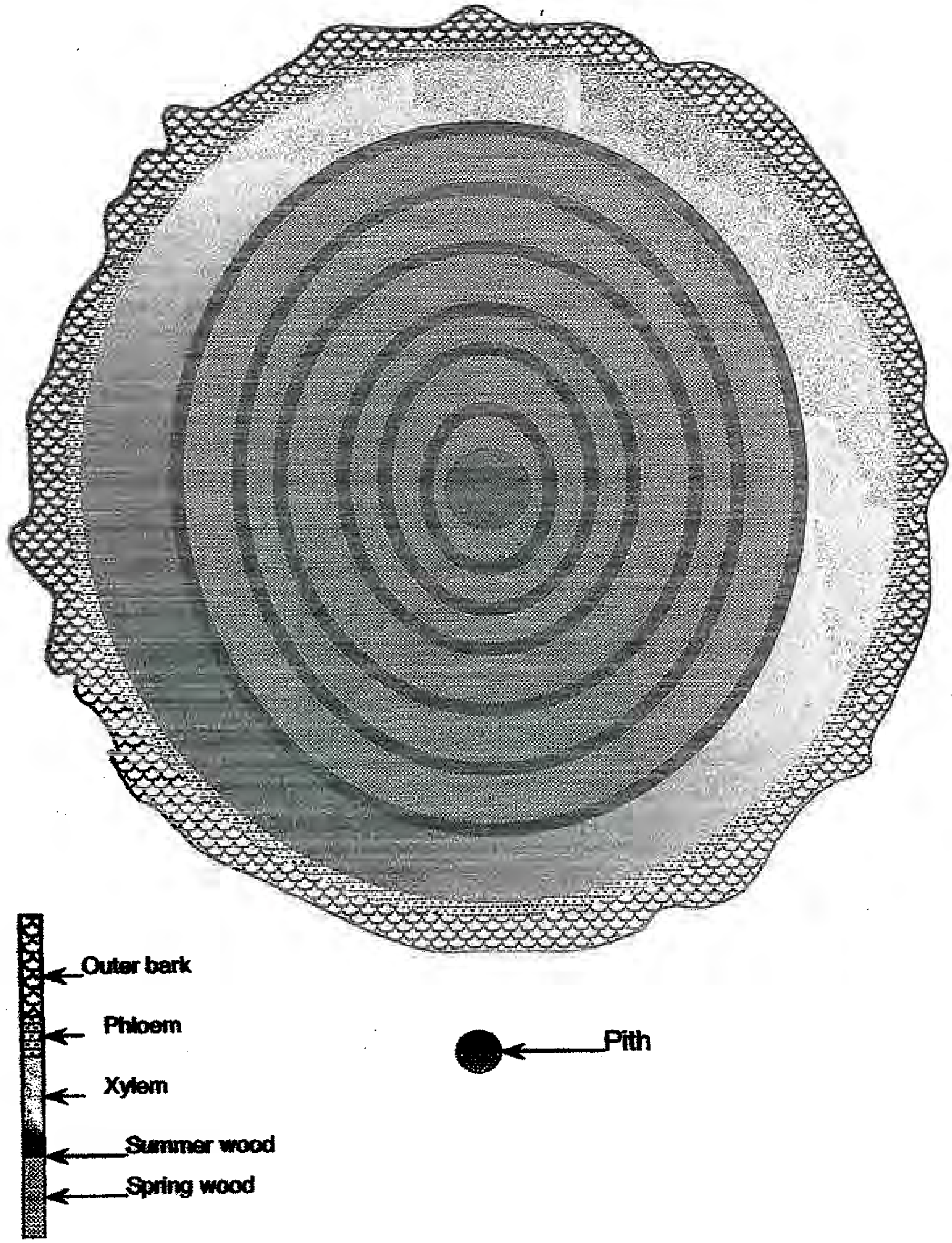


2 year old seedling at time of planting. Increment boring was taken at 6 inches above ground level.



HEYBURN STATE PARK
INCREMENT BORINGS FROM CENTRAL AREA

TREE CROSS SECTION SHOWING PITH, SPRING WOOD, SUMMER WOOD, SAPWOOD (XYLEM & PHLOEM), & OUTER BARK



PICTURES

HEYBURN STATE PARK
WASTE WATER APPLICATION
PROJECT

(proposed)

Pictures taken May 2008
by: R. A. Wheeler

OPEN AREA WITHIN THE PROJECT. CONTRIBUTES TO THE LOWER TREE COUNT FOUND IN THE TIMBER CROUSE. . Note the wide spacing between the P.P.. May 2008

Dense litter and duff layer. May 27, 2008

Cluster elkweed May 27, 2008

Existing debris pile in
Treated area adjacent to
The North Strip

Mature P. P. May 2008

Tall understory in the
North Strip

Large non stocked area

Closed canopy in the
North Strip

Closed canopy in the
North Strip

Timber in the North Strip

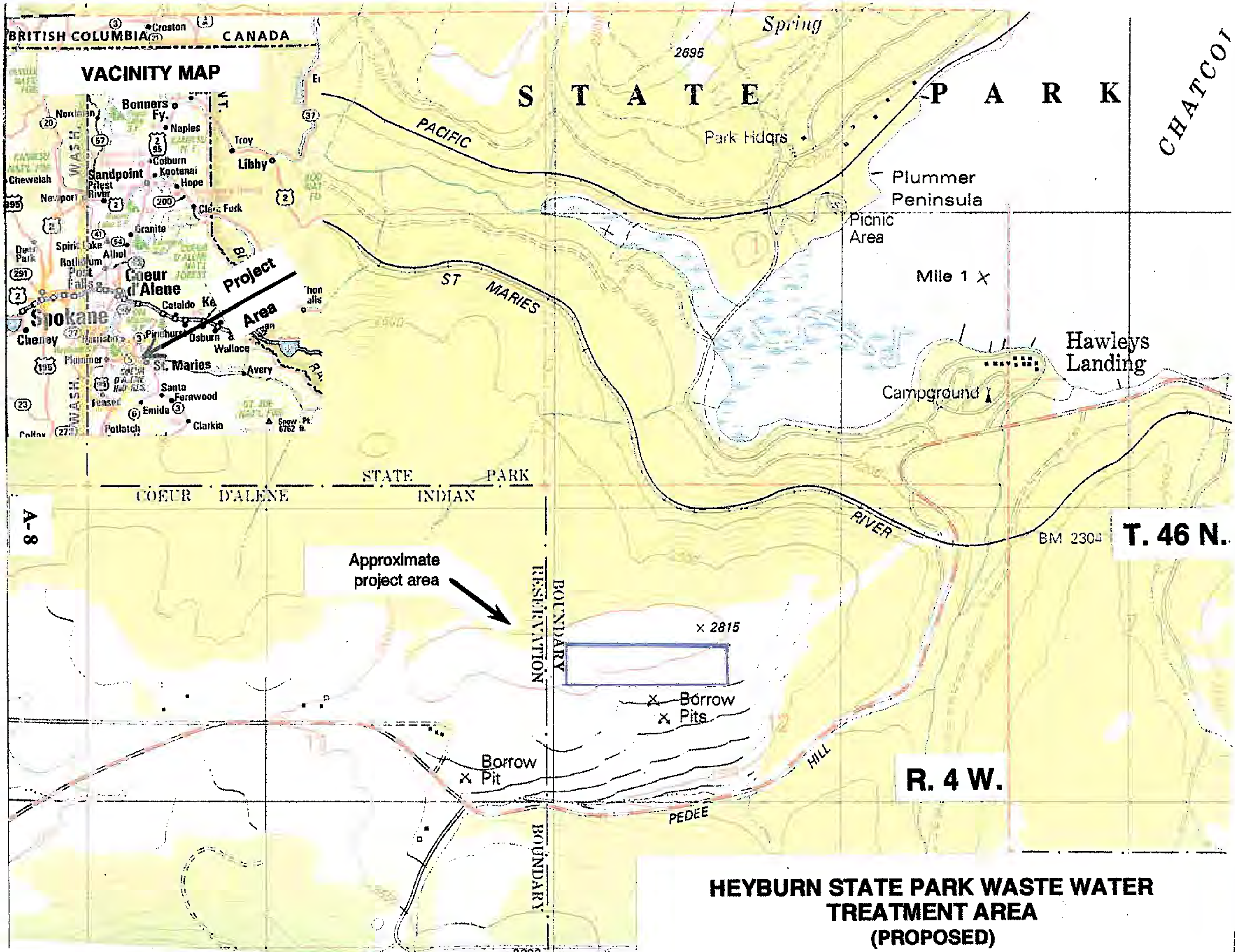
Oregon grape in a debris disposal area

Large non stocked area

Tall understory in the North Strip

Center Area

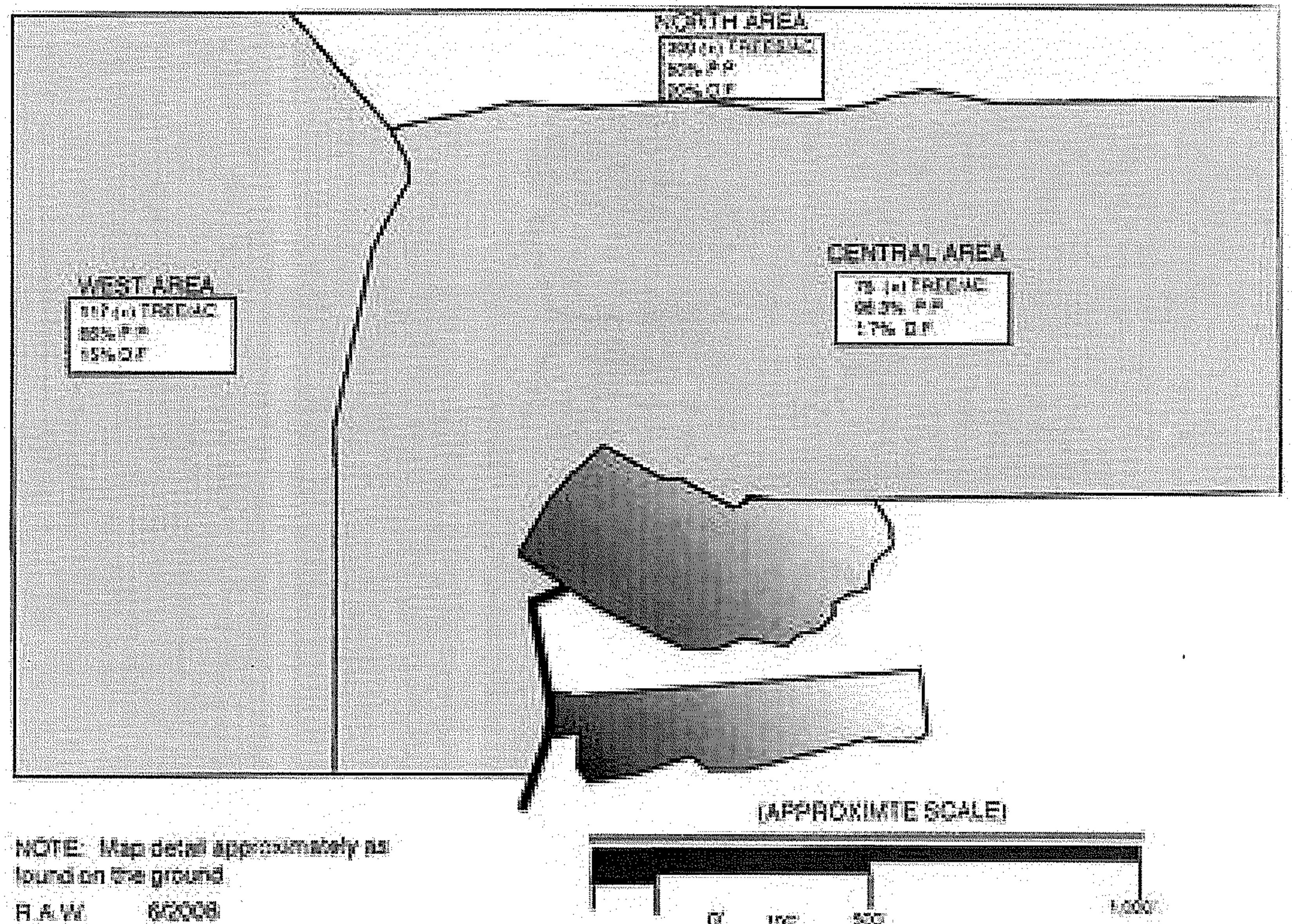
Timber in the North Strip



A-8

HEYBURN STATE PARK WASTE WATER TREATMENT AREA (PROPOSED)

HEYBURN STATE PARK TIMBER TYPE MAP



NOTE: Map detail approximately as found on the ground

R.A.W. 6/2008

APPENDIX D: STRATA GEOTECHNICAL ENGINEERING REPORT

STRATA

GEOTECHNICAL ENGINEERING & MATERIALS TESTING

Integrity from the Ground Up

September 17, 2008
File: BROCAL C08025A

Mr. Shawn Wilson
Brown and Caldwell
600 E. Riverpark Lane, #210
Boise, ID 83706

RE: **REPORT**
Geotechnical Engineering Evaluation
Proposed Central Sewage Collection and
Treatment Facility
Heyburn State Park
Benewah County, Idaho

Dear Mr. Wilson:

Strata, Geotechnical Engineering and Material Testing, Inc. (STRATA) has performed our authorized geotechnical engineering evaluation for the proposed Central Sewage Collection and Treatment Facility to be located at Heyburn State Park in Benewah County, Idaho. The purpose of this evaluation was to assess subsurface soil conditions at the site and provide geotechnical recommendations to assist project planning, design and construction. We accomplished our geotechnical services in reference to our proposal dated April 25, 2008. You authorized our services via the *Brown and Caldwell Standard Subcontract for Geotechnical Services* dated July 17, 2008.

This report summarizes our field evaluation, laboratory testing, engineering opinions and geotechnical recommendations. Geologic conditions observed at the site, in conjunction with soil engineering and construction characteristics, are presented in the following report. We provide specific recommendations for preparing the site, pond construction, foundation preparation and earthwork construction. The geotechnical recommendations presented herein must be read and implemented in their entirety. Individual sections or portions within this report cannot be relied upon without the supporting text.

Project success will be enhanced by adhering to our report recommendations, following good construction practices and providing necessary construction monitoring, testing and consultation to verify the work has been completed as recommended. We recommend STRATA be retained on the owner's behalf to provide construction material testing during construction to verify our geotechnical recommendations and to provide project quality assurance.

Based on our conversations, we understand Brown and Caldwell plans to provide this geotechnical report as a *reference document* in the project plans and specifications for bidding purposes. We recommend Brown and Caldwell incorporate limitations for using this report such that the specifications reflect that contractors may review the report for information purposes only. The geotechnical report was prepared for Brown and Caldwell and the Idaho State Department of Parks and Recreation to assist civil design and plan and specification development. Project plans and specifications should be relied upon for bidding purposes; STRATA's geotechnical report should not be construed as project specifications and should only be relied upon at the contractor's sole risk.

We appreciate the opportunity to work with you on this project. Please do not hesitate to contact us if you have any questions or comments.

Sincerely,
STRATA, Inc.

Cole W. Warrick, P.G.
Project Geologist

PROFESSIONAL ENGINEER
REGISTERED
9-17-08
12744
STATE OF IDAHO
CHRIS M. COMSTOCK

Chris M. Comstock, P.E., P.G.
Project Engineer

H. Robert Howard, P.E.
Senior Engineer

REPORT
Geotechnical Engineering Evaluation
Proposed Central Sewage Collection and
Treatment Facility
Heyburn State Park
Benewah County, Idaho

PREPARED FOR:
Mr. Shawn Wilson
Brown and Caldwell
600 E. Riverpark Lane, #210
Boise, ID 83706

PREPARED BY:
STRATA, Inc.
280 W. Prairie Ave.
Coeur d'Alene, ID 83815

September 17, 2008

IDAHO MONTANA NEVADA OREGON UTAH WASHINGTON WYOMING
www.stratageotech.com

TABLE OF CONTENTS

REPORT

Geotechnical Engineering Evaluation
Proposed Central Sewage Collection and Treatment Facility
Heyburn State Park
Benewah County, Idaho

INTRODUCTION

STRATA is pleased to provide this geotechnical engineering evaluation for the proposed Central Sewage Collection and Treatment Facility to be located at Heyburn State Park in Benewah County, Idaho. The purpose of our geotechnical engineering evaluation was to assess the subsurface soil conditions within the proposed project area and prepare geotechnical recommendations to assist project planning, design and construction. We accomplished our services in reference to the authorized scope of geotechnical services dated April 25, 2008. To accomplish our geotechnical evaluation, we performed the following:

1. Subcontracted a private utility locating service to help reduce the potential for damaging existing utilities.

2. Coordinated with Mr. Jordan Neilson, Scientist II, with Brown and Caldwell, to help locate the proposed exploration locations in the field.

3. Observed 22 test pit excavations within the development area. We estimated test pit locations using global positioning system (GPS) methods and from existing topography. We logged the subsurface profiles and visually described and classified the soil encountered in reference to the *Unified Soil Classification System* (USCS). Select samples were retained for laboratory testing. We retained additional samples for future analytical testing, if required.

4. Performed two hand auger explorations where access with excavation equipment was limited.

5. Performed infiltration testing to estimate percolation characteristics for surficial soil at the land application site.

6. Performed laboratory testing including grain-size distributions, in-situ moisture and density relationships, Atterberg limits, pH and resistivity. We used laboratory tests to help characterize soil engineering properties and provide soil classifications.

7. Performed engineering analyses to provide geotechnical design and construction recommendations for:

- Earthwork, including:
  - *Reusability of on-site soil*
  - *Site preparation*
  - *Rock and soil excavation*
  - *Benching requirements*
  - *Wet soil/wet weather construction*
  - *Compaction requirements*
- Foundation design including:
  - *Coefficient of sliding friction (f_s)*
  - *Concrete slab-on-grade floor preparations and vapor protection*
  - *Modulus of subgrade reaction (k)*
  - *Required frost depth for footing embedment*
- Seismic consideration including:
  - *IBC site class*
  - *Spectral response accelerations*
  - *Liquefaction potential*
- Lined pond considerations
- Recommended slope configurations
- Pond site slope stability
- Surface and subsurface drainage
- Additional recommended services

8. Prepared and provided four copies of this geotechnical report including exploration logs, site plan and laboratory test results.

EXISTING SITE AND GEOLOGIC CONDITIONS

Geologic Conditions

The general soil and bedrock geology at the site is complex and encompasses both igneous and sedimentary geologic units. We reviewed the geologic interpretation shown on the *Geologic Map of the Coeur d'Alene 30 x 60 Quadrangle, Idaho* Breckenridge and McFadden, 2002. Geologic mapping indicates the project site is underlain by 3 major geologic soil and rock units including: 1) lake and stream sediments, 2) basalt and 3) metamorphic quartzite, siltite and argillite. We generally identified the lake and stream sediments and basalt units in our exploratory test pits; however, we did not encounter metamorphic units.

Geologic history in the project vicinity includes lake and stream sediments deposited and reworked by gravity along slopes and drainages. Prior to sediment deposition, basalt flows covered the majority of the landscape. Basalt is generally encountered below the sediments at this site. However, the authors indicate these sediments can be occasionally deposited as interbeds between basalt flows. The soil and geologic conditions encountered during our exploration are generally consistent with the published soil and geological information described above.

Proposed Treatment Site – Area 1

We divided the project into two general areas based on the separated nature of the proposed construction and for clarity. We will refer to the proposed treatment site as "Area 1" and the site slated for Storage Pond No. 2 and for land application as "Area 2."

The existing site topography for Area 1 includes east facing slopes ranging in inclination from relatively flat to approximately 1.5H:1V (Horizontal to Vertical). One drainage traverses east to west along the south portion of the site.

We accessed Area 1 from a primitive road that connects to Chatcolet Road, east of the area. Area 1 is bordered to the north by the access road and to the south by undeveloped and densely forested land. To the west is an existing hiking trail and to the east is State Highway 5. We estimate total topographic relief for Area 1 as approximately 140 feet.

Proposed Land Application and Storage Pond Site – Area 2

The existing site topography for Area 2 includes undeveloped, moderately forested land with slopes ranging from relatively flat to maximum slopes of 3H:1V. We accessed the site from a primitive construction road south and east of the area. Area 2 is bordered to the north, south and west by undeveloped land. The topographic map did not indicate any major drainages in Area 2; however, the general surface gradient was observed to slope down to the southeast. We estimate total topographic relief in Area 2 as approximately 50 feet.

PROJECT UNDERSTANDING

General

We understand a new sewage collection and treatment facility is planned to service the Heyburn State Park and surrounding area. We understand sewage effluent from Heyburn State Park camp sites will be treated at Area 1 and then pumped to a storage pond at the upper, elevated portion of Area 1 and also to a storage pond in Area 2 where treated effluent will be land-applied. The project generally includes a headwork's building, earthen embankments for treatment ponds, settling ponds, storage ponds, a chlorine contact basin and effluent pump station. The project will also include various pipelines, road improvements, and railroad and stream utility crossings. You requested STRATA provide geotechnical recommendations for only pond earthwork and foundation aspects and not for utility infrastructure aspects. The following paragraphs describe our proposed construction understanding specific to each development area.

Proposed Construction – Area 1

Area 1 includes the proposed effluent treatment site as illustrated on Plate 1, *Site Plan – Area 1*. We understand a lined storage pond (Storage Pond No.1) is planned in the west elevated portion of the area, measuring approximately 200 feet long and 150 feet wide. Two treatment ponds measuring 200 feet long by 75 feet wide and two approximate 70 foot-diameter settling ponds are planned east of the storage pond. The treatment ponds and settling ponds will range from 11 to 17 feet deep with inboard pond side slopes of 3H:1V and outboard slopes of 2H:1V. The ponds will be lined with either heavy duty HDPE or PVC liners. The treatment and settling ponds will generally include cuts for the uphill embankments and structural fill for downslope embankments. Cuts and fills for the proposed treatment and settling ponds are on the order of 5 to 20 feet. Storage Pond No. 1 will likely be cut into the elevated bench on the order of 18 to 20 feet. We understand the grading plan you provided at the time of our report was the most recent version based on the available geotechnical data and your civil design. However, we anticipate this grading plan may require slight revision prior to final design or during construction to accommodate actual soil conditions between test pit locations.

The proposed construction for Area 1 will also include a headworks mechanical building. We understand walls will be concrete masonry unit (CMU) construction and foundations will be lightly loaded (less than 2 kips per lineal foot). Shallow continuous foundations with concrete slab-on-grade floors are planned.

Development for Area 1 will also include improvements to the existing access road along the north side of the project and new access roads for the treatment ponds and the west side storage pond. We understand these roads will be gravel surfaced and not be paved with asphalt concrete pavement. Underground piping utilities will transfer effluent between various ponds and pump stations. Utility trenches are planned to extend 3 to 5 feet below the existing ground surface, depending upon actual subsurface conditions and whether the pipelines are gravity fed or pressurized.

Proposed Construction – Area 2

Area 2 includes the land application and Storage Pond No. 2 portion for the sewage collection and treatment facility project as illustrated on Plate 2, *Test Pit Location Plan – Area 2*. The proposed Storage Pond No. 2 construction is presented in an inset on Plate 3, *Inset – Area 2*. We understand the storage pond will be about 225 feet long by 175 feet wide and up to 18 feet deep. Cuts and fills for the storage pond are estimated to be on the order of 10 to 12 feet. Area 2 will also include construction for underground piping for the proposed sprinkler system to apply treated effluent.

FIELD AND LABORATORY EVALUATION

We evaluated subsurface soil conditions at the site by observing 22 test pits on May 7 and 8, 2008. During fieldwork, we interacted with Mr. Jordan Nielson with Brown and Caldwell to help document exploration locations. Because the area was heavily wooded, accurate test pit locations were difficult to determine. However, we used a consumer grade GPS unit at the time of excavation to help document latitude and longitude for each test pit. We correlated latitude and longitude to available Google Earth™ data to help illustrate test pit locations as shown on Plate 1 and Plate 2. We specifically note that test pit locations were not surveyed prior to exploration and their locations are considered approximate.

To accomplish excavation, the excavation subcontractor used a track-mounted JD490D excavator equipped with a 36-inch wide bucket. Test pits ranged in depth from 2.5 to 15.5 feet below the existing ground surface. The excavation subcontractor loosely backfilled the test pits at the conclusion of the exploration activities. Test pit backfill was not landscaped or compacted. We recommend the loose test pit backfill be completely removed to undisturbed native soil and backfilled with structural fill placed and compacted as recommended herein. Replacing loose backfill with structural fill will help reduce the potential for isolated settlement.

We visually described and classified the soil encountered referencing the USCS and we logged the soil profile. We transported samples to our laboratory for further evaluation, laboratory testing and storage.

Although the soil conditions encountered in the test pits were somewhat consistent with respect to soil type, significant variations may exist between exploration locations. These variations would not be apparent until construction. Where such variations exist, they may impact the opinions and recommendations presented in this report, as well as construction, including timing and costs. Specifically, it is highly probable that basalt bedrock depths and elevations could vary between test pit locations.

SUBSURFACE CONDITIONS

We generally encountered 3 soil and rock units in exploration locations including 1) silt and clay, 2) silty sand and silty gravel and 3) basalt bedrock. Appendix A provides detailed descriptions of the subsurface conditions encountered during exploration as shown on exploratory logs. A summary of the USCS is also provided in Appendix A and should be used to interpret the terms used on the exploration logs and throughout this report.

Subsurface Conditions – Area 1

We evaluated the subsurface soil and bedrock conditions for Area 1 by observing test pits TP-9 through TP-18 and performing hand-excavations HA-1 and HA-2. Exploration locations for Area 1 are illustrated on Plate 1.

Silt and Clay

In Area 1, we encountered silt and clay with variable sand, gravel, cobble and boulder content. The silt and clay ranged from stiff to hard and contained vegetation and organics (topsoil) extending from 6 to 8 inches below the gravel surface. The silt and clay in TP-9 and TP-15 were highly indurated and caused trackhoe refusal. The silt and clay extended to the maximum depths explored in TP-9 and TP-15. The silt and clay extended to the silty sand and silty gravel in TP-16 through TP-18 at depths of 1.5 to 7 feet. The silt and clay extended to the basalt bedrock surface at a depth of 4 to 7 feet in TP-10 through TP-14.

Silty Sand and Silty Gravel

We encountered silty sand and silty gravel with variable silt, cobble and boulder content below the silt and clay in TP-16 through TP-18. Generally, the sand and gravel is colluvial soil that exists as a mixture of weathered basalt bedrock, alluvium, and silt and clay. The sand and gravel also contained boulders ranging from 4 to 6 feet in diameter. The boulders generally increased in frequency with depth, with the exception of TP-17 where the silty sand contained trace gravel and cobbles. In TP-16 through TP-1, the sand and gravel extended to the maximum depths explored of 6 to 15.5 feet. TP-16 was terminated due to refusal on a 6-foot-diameter boulder.

Basalt Bedrock

We encountered basalt bedrock in TP-10 through TP-14. The basalt was generally gray, slightly to moderately weathered, moderately to highly fractured and vesicular. The exploration equipment was able to penetrate the basalt surface from a few inches to 3 feet.

Subsurface Conditions – Area 2

We evaluated the subsurface soil and bedrock conditions for Area 2 by observing TP-1 through TP-8 and TP-19 through TP-22.

Silt and Clay

We encountered silt and clay in Area 2 at the ground surface, which was similar to the silt and clay observed in Area 1. The silt and clay typically contained vegetation and organics (topsoil) to a depth of 6 to 10 inches below the existing ground surface. The silt and clay generally extended to the basalt bedrock surface in each test pit except TP-6. However, we encountered a thin silty gravel layer in TP-4 and TP-8 immediately above the bedrock surface.

Silty Sand and Silty Gravel

We encountered a silty gravel layer below the silt and clay in TP-4 and TP-8 similar to the silty gravel described above in Area 1. The silty gravel extended to the bedrock surface in TP-4 and TP-8 at a depth of 3 and 3.5 feet, respectively.

Basalt Bedrock

We encountered basalt bedrock below either silt and clay or silty gravel in each test pit except TP-6. The basalt bedrock was similar to the basalt described for Area 1; however the basalt was generally less weathered. The JD490D excavator was able to penetrate the basalt bedrock between a few inches and up to 3 feet in TP-19. Generally, the basalt bedrock appeared to be more competent at higher site elevations and was more fractured at lower site elevations, which allowed for greater excavation into the bedrock surface.

Groundwater

STRATA did not encounter groundwater in any test pit location at the time of exploration. However, groundwater and soil moisture will vary depending on rainfall, irrigation practices and/or runoff conditions not apparent at the time of our field evaluations. We anticipate that if groundwater is encountered it would be located along the soil and rock contacts as minor seeps and springs. Groundwater likely exists within soil interbeds or within fractured basalt bedrock greater than 50 feet below the ground surface in the locations explored.

LABORATORY TESTING

STRATA performed laboratory testing on select samples obtained during our subsurface exploration to assess engineering and physical properties for the soil encountered during our exploration. Laboratory testing included in-situ moisture and density content, Atterberg limits, grain-size distribution, maximum dry density, optimum moisture content and pH. We performed laboratory tests in reference to ASTM testing procedures and the results are presented in Appendix B and on individual exploration logs.

ANALYSES

STRATA utilized our field and laboratory testing in conjunction with our project understanding to perform engineering analyses for specific areas of this project. We performed analyses for significant planned aspects of construction (i.e. pond embankments, foundations and cut and fill slope stability).

STRATA performed our geotechnical analyses using subsurface soil information from the authorized exploration and laboratory testing scope. If development plans change, or if unforeseen conditions are exposed during construction, STRATA should be consulted to review our recommendations and provide any necessary revisions or modifications. The following sections summarize our analyses.

Global Stability

We used the computer software SLOPE/W to estimate cut and fill stability. SLOPE/W searches for the potential failure circle with the lowest factor of safety by calculating many safety factors on different potential failure planes using various slope stability analyses. Specifically, we used the Morgenstern-Price method. In our analyses, potential failure planes were evaluated in various locations, intended to model critical slope configurations based on our review of present project plans.

We assumed the native soil within embankments will become saturated from possible pond leakage or subsurface moistures. However, we did not incorporate groundwater or hydrostatic pressure into the model since we did not encounter groundwater during exploration and because the ponds will likely be designed with an underdrain system. We reviewed our soil strength data from nearby projects and also correlated index laboratory test results to soil strength parameters. We also used field and laboratory data to estimate soil unit weight. Our slope stability parameters are as follows:

Table 1. Assumed Soil Parameters for Slope Stability

Parameter	Value assumed
Soil Friction Angle	32 degrees
Soil Cohesion	0 (neglected)
Saturated Soil Unit Weight (fill and native soil)	125 pounds per cubic foot

We understand proposed cut and fill slope inclinations are 2H:1V for slopes outside of pond liner areas. Inboard pond slopes are currently configured at 3H:1V. From our experience and referencing typical geotechnical standards of practice, where there is a risk of property damage, but the site surface and subsurface geometry is adequately known, it is typical to require a minimum factor of safety for slope stability of 1.5. We consider this to be the case for this project and have, therefore, assumed a minimum factor of safety of 1.5 for our stability analyses as acceptable for this project.

Fill Slopes

To evaluate fill slopes, we estimated approximate embankment heights and configurations to provide Brown and Caldwell preliminary feedback regarding fill slope stability. Our initial analyses indicated fill slopes constructed at 2H:1V would be stable with a factor of safety greater than 1.5. This assumes on-site silt and clay will be used as structural fill when constructing embankments and that our recommendations are followed. If the silt and clay soil contains sand, gravel or cobbles, the soil's strength will be equal or greater and will still meet the intent of our recommendations presented throughout this report. We understand Brown and Caldwell used the information from our preliminary analyses to accomplish grading plans for the project. Brown and Caldwell subsequently provided STRATA with the most current version of the grading plan including Sections A through F as shown on the project plans *Treatment Facility Site Sections – 1.* Based on our review of the sections, Section F appears to be the most critical because it is constructed as the highest embankment with the steepest slope. Our geotechnical analyses predict safety factors for the configuration shown in Section F of approximately 2.13 for static and greater than 1.1 for dynamic conditions (i.e. earthquake).

We neglected cohesion in our slope stability analyses. However, silt and clay soil in the Coeur d'Alene Lake area typically exhibit *unsaturated* cohesion values on the order of 500 to 1,500 pounds per square foot (psf) in addition to the estimated soil friction angle. Such high cohesion values will cause slope stability predictions to be much greater than presented above. Since the silt and clay soil are relatively impermeable and pond side slopes are greater than 5H:1V, most precipitation will likely runoff and not infiltrate the subsurface or saturate the soil. Such soil saturation can reduce soil cohesion via changing soil water contents. However, the silt and clay will maintain some cohesion even when saturated. Thus, our slope stability analyses are conservative and estimated safety factors presented above will likely be higher than predicted.

Based on the above discussion, our assumptions and experience, the fill configurations presented on the current project plans appear to meet the standard of practice for predicted slope stability in the north Idaho area.

<u>Cut Slopes</u>

STRATA evaluated cut slopes in a similar manner as described for fill slopes above. We evaluated Section C shown on the *Treatment Facility Site Sections – 1* sheet of the project plans as the most critical cut slope. We evaluated the cut slope stability assuming the entire cut slope will be constructed of on-site soil. However, after reviewing TP-14 and TP-15, basalt bedrock may be encountered in the cut slope shown on Section C. The cut slope shown predicts a safety factor of greater than 1.5. Additionally, if bedrock will be encountered in the cut slope, which is likely, the predicted safety factor will likely be higher due to the bedrock's relatively high strength. Our opinion is the cut slope shown on Section C is predicted to meet the geotechnical standard of practice for slope stability.

Embankment Settlement

Fill embankments will settle with time as the fill comes to equilibrium under its own weight. The rate of settlement will be highly dependent on the type of structural fill selected for the embankment and the compaction level achieved. From our analyses, we anticipate silt and clay soil used for embankments will settle up to approximately 0.5 to 1 percent of the total fill height. A small fraction of that settlement will occur from the foundation soil's elastic response to loading. We estimate about 50 to 70 percent of the total embankment settlement will occur prior to construction completion and pond liner installation. If soil placement and compaction effort does not conform to the requirements detailed in the *Structural Fill* section or the required compaction is not achieved, the risk of higher embankment settlement is increased. In addition, water migration into the embankments will increase the amount of settlement. The maximum embankment height for the grading plan provided appears to be on the order of 13 to 14 feet at its thickest. This corresponds to an estimated fill settlement of approximately 1 to 1.75 inches. This settlement criteria has generally been field verified to be an appropriate preliminary estimate for embankment settlement. However, if our recommendations are followed and the contractor accomplishes good construction practices, embankment settlement will likely be even lower. To help offset the impacts of settlement up to 1.75 inches, the embankment can be crowned slightly or provide a small (e.g. 2-inch) camber.

GEOTECHNICAL OPINIONS AND RECOMMENDATIONS

The following specific geotechnical opinions and recommendations are presented to assist planning, design and construction for the proposed Central Sewage Collection and Treatment Facility to be located at Heyburn State Park in Benewah County, Idaho. We have separated portions of our opinions and recommendations into the two project areas described earlier in the report. If not explicitly stated and if recommendations are not provided for each area, the following opinions and recommendations are applicable to *both* project areas.

Earthwork

The project site encompasses a variety of soil and rock conditions, slope angles, grading locations and is proposed to be developed under a relatively complicated grading plan with numerous cut and fill configurations. Further, we expect the mass grading approach to vary with the selected contractor and the time of year. As such, it will be very difficult to predict actual soil types and where such soil will be placed as structural fill to construct embankments, foundation pads, etc. Our opinion is the project will require overall geotechnical guidelines and criteria for grading, as opposed to strict controls on where soil will be excavated, processed and placed as structural fill. The following recommendations are intended to address all anticipated aspects of grading and earthwork in a general manner that allows contractor flexibility, but generates a product that meets the intended project use and adheres to the geotechnical recommendations contained herein. Mass grading under these circumstances is dynamic and requires good communication between the owner, contractor and design team. Finally, it will be critical to provide adequate quality control and quality assurance to verify the intent of the project specifications and this report are followed.

Soil Excavation Characteristics – General

Initial site preparation will involve stripping any soil containing appreciable vegetation or organics (topsoil) from proposed pond construction areas, roadway subgrades and building subgrades. Topsoil thickness ranged from about 6 to 18 inches and averaged about 9 inches. However, deeper stripping may be required where thicker concentrations of organic material may be encountered, such as near large trees. The topsoil may be reused for landscaping or removed from the site. Topsoil should not be reused as structural fill due to the presence of vegetation and organics. After achieving the subgrade, the contractor must take precautions to protect the subgrade from becoming disturbed or saturated. Therefore, we recommend the contractor limit construction traffic, exposure to precipitation and other sources of water to the subgrade. Subgrades must be graded to aggressively direct surface water off subgrades to avoid infiltration.

Based on our project understanding, significant cuts and fills are planned at the site. Such mass grading procedures will likely produce structural fill products that are a mixture of clay, silt, sand, gravel and cobbles. The fill composition will vary with the contractor's means, methods, processing procedures, excavation area and depth and many other factors. We anticipate the processed structural fill soil (i.e. soil excavated, transported and placed as fill) being placed across the site will vary in soil type as the above ratios of soil constituents will vary with locations and the contractor's means and methods. It will be critical to the project's success that adequate quality control of soil compaction occurs during all aspects of mass grading. Quality control and accurate characterization of moisture-density relationship curves (Proctor) will be extremely important to verify compaction specifications are achieved. Further, such soil mixing and soil type variations should be accounted for in project specifications. It will be important to provide the contractor with flexibility in soil type to avoid the requirement for excessive soil processing and possible fill wasting, which may negatively impact project schedules and costs. While the silt and clay soil are expected to control the site's earthwork characteristics, the inclusion of sand, gravel and cobbles in fill products will not significantly impact the soil's engineering characteristics. Our recommendations throughout this report reflect the potential for such variations in soil composition. Given the above considerations, we strongly recommend STRATA be retained to provide earthwork quality control during construction to work with the contractor and Brown and Caldwell to verify soil compaction and help reduce unnecessary project delays.

The soil encountered during exploration may be excavated using conventional soil excavation techniques. Trenches excavated below 4 feet in soil will require excavations to be sloped back at 1.5H: 1V (Horizontal to Vertical). Alternatively, trenches and excavations may be shored or braced in accordance with the OSHA regulations and local codes.

Rock Excavation Characteristics- General

We anticipate bedrock or large boulders will be encountered in each area. We anticipate soil containing large boulders and competent basalt bedrock requiring blasting or hydraulic hammering will impact excavation activities. Large basalt boulders in isolated areas may require equipment with mechanical thumbs to manipulate and dispose of boulders. Excavations into competent basalt bedrock will require ripping, hydraulic hammering and/or blasting. We recommend you consider incorporating the following into project plans and specifications:

- Blasting and earthwork contractors are ultimately responsible for the method of bedrock excavation and safety.
- Bedrock is defined as soil or rock, which cannot be excavated using equipment with a 24-inch-wide short-radius-tip bedrock buckets with a bucket-curling force not less than 28,000 lbf and stick-crowd force not less than 18,500 lbf; measured according to SAE J-1179. Material which cannot be excavated using the above equipment may

be considered bedrock from a pay-unit standpoint. Bedrock excavation includes removal and disposal. If the above equipment is used and cannot excavate the material, it may be classified as rock excavation with associated pay factors.

- Weathered bedrock is expected to be rippable and excavated with large equipment and is not considered rock excavation from a pay-unit standpoint.

- Trench excavation into bedrock shall be performed with late-model, track-mounted hydraulic excavators (Caterpillar 345 or larger); equipped with a 24-inch wide, maximum, short-tip-radius bedrock buckets; rated at not less than 140-hp flywheel power with a bucket-curling force not less than 28,000 lbf and stick-crowd force not less than 18,500 lbf; measured according to SAE J-1179. Mass rock excavation via ripping shall be accomplished with Caterpillar D-8 or larger equipment.

- Experience has shown that a minimum 7,500 lb hoe ram is required to breakout basalt bedrock when not fractured or weathered. Bedrock requiring hoe rams for excavation shall be paid as bedrock excavation.

- Bedrock excavation shall be measured as the neat cut lines required for mass grading, trench and utility construction plus 1 foot laterally on each side of the trench. Bedrock breakout and required backfill beyond these limits should not be paid.

- “Over-blasting” below the design subgrade will require excavation to relatively undisturbed bedrock and backfilling with structural fill. If over-blasting is determined to be less than 24 inches below design subgrade, a 10-ton or larger, smooth-drum, vibratory roller having a dynamic force of at least 30,000 pounds per impact per vibration and at least 1,000 vibrations per minute shall make at least 6 complete passes or until STRATA determines a dense and interlocking subgrade has been established.

- For reuse as granular structural fill, blasting, hammering or ripping must reduce the excavated bedrock to a maximum particle size of 12 inches unless oversize bedrock boulders are removed from structural fill products.

- The contractor shall submit a blasting plan to the project engineer prior to initiating blasting. It will be the contractor’s responsibility to secure appropriate regulatory permits and notify adjacent property owners.

Rock Excavation - Area 1

We anticipate basalt bedrock and highly indurated silt and clay to impact underground utility construction and pond excavation in Area 1. We encountered competent bedrock ranging in depths from 2.5 to 9 feet in TP-10 through TP-15. The elevation of the basalt bedrock will vary significantly across the site. We also anticipate that ripping highly indurated silt and clay may be required in isolated areas. Additionally, our test pits encountered several areas where very dense alluvial sand, gravel, boulders and cobbles existed immediately above the basalt bedrock surface. These boulders and cobbles may be difficult to excavate, but will not likely require blasting if the excavation is not confined.

Rock Excavation - Area 2

We anticipate competent basalt rock requiring blasting or hydraulic hammering will be needed for utility inverts or subgrades planned more than 2 feet below the subgrade. Generally, higher elevations encountered more competent basalt bedrock while lower elevations encountered more fractured bedrock, in which we were able to penetrate a few feet. The contractor should anticipate encountering occasional cobbles and boulders in Area 2.

Rock Subgrade Preparation

Basalt rock subgrades will likely be too coarse to perform maximum dry density testing in accordance with Proctor procedures. Therefore, we recommend compaction of basalt subgrade be evaluated by proofrolling. Proofrolling efforts at the disturbed rock subgrade must verify the disturbed rock is less than 12-inches thick. Proofrolling must be accomplished with at least 5 full passes of a vibratory roller having a minimum 10-ton static drum weight to a firm and unyielding surface. If the surface is not firm and unyielding, additional passes should be made until the surface is firm and unyielding. Any unstable areas should be removed and replaced with granular structural fill. We recommend STRATA observe proofrolling operations. If the rock subgrade surface is not over-blasted and contains less than 6 inches of disturbed rock, subgrade may be prepared by removing the loose rock and placing structural fill or concrete directly over undisturbed basalt bedrock.

Soil Subgrade Preparation

The following recommendations apply to all soil subgrades at the project including, but not limited to, embankment fills, foundations, slabs, roadways, etc. Following topsoil stripping, we recommend the upper 8 inches of subgrade underlying all embankments, foundations, slabs, roadways or any area to receive structural fill or concrete be scarified, moisture conditioned and compacted to at least 92 percent of ASTM D 1557 (Modified Proctor). Compacting the subgrade will help establish firm and stable conditions from which to construct structural fill or structures and will help identify soft or unstable soil areas. The subgrade should be free from standing water, pumping soil, vegetation or organics and any particles larger than

8 inches in mean diameter. Subgrade soil containing more than 30 percent particles larger than 3/4-inch-diameter is too coarse for performing an ASTM D 1557 test and should be compacted using a method specification as outlined in the *Structural Fill* section. Soft or wet areas that cannot achieve sufficient compaction may need to be over-excavated and replaced with granular structural fill, as discussed in the *Wet Weather/Soil Construction* section.

Structural Fill

<u>General</u>

Any fill placed at the project site should be placed as structural fill. Structural fill should be classified as CL, ML, SP, SM, SW, GP, GW or GM in accordance with the USCS. Granular type structural fill for over-excavations, pavements or foundation and slab support should be classified as SP, SW, GP or GW according to the USCS. Granular type structural fill should not contain more than 9 percent passing the No. 200 sieve (fines) and should adhere to subbase and base course requirements presented in the most recent version of the *Idaho Standards for Public Works Construction* (ISPWC). Structural fill should not contain particles larger than 8 inches in diameter except as recommended for rock that is excavated or blasted and processed as described herein. The civil designer should consider limiting structural fill in trench backfill and adjacent to structures to soil containing particles no larger than 3 inches in mean diameter. However, placing soil with particles larger than 3 inches will not impact our recommendations and geotechnical criteria, but could damage structures such as foundations and piping. Any soil with particles larger than 3 inches should be a well graded mixture and not contain voids larger than ¼-inch. This may require frequent fill soil evaluation during excavation and placement to verify no voids exist in structural fill. Additional particle size considerations for re-using shotrock are provided in subsequent sections.

We recommend structural fill be appropriately moisture-conditioned for compaction and placed in loose horizontal lifts no thicker than 12 inches. Each lift of structural fill should be compacted to at least 92 percent of the maximum dry density of the soil as determined by ASTM D 1557 (Modified Proctor). Structural fill should never be placed over topsoil, undocumented fill, wet or frozen subgrades, or other unsuitable materials. We recommend STRATA be retained to perform compaction testing and observe fill placement to verify our recommendations are followed during construction.

Site Soil

The on-site soil is suitable for reuse as structural fill, but it is highly moisture-sensitive and may be difficult to recompact. Any on-site soil will also contain a variable mixture of sand, gravel and cobbles; however, the silt and clay content of structural fill will control the compaction and earthwork characteristics of the soil. We specifically note that the on-site soil will vary in composition as the contractors processing, moisture conditioning efforts and construction staging will also vary. However, the majority of on-site soil used as structural fill is expected to primarily consist of silt and clay.

The on-site soils' in-situ moisture content varied from approximately 16.9 to 29.2 percent. The optimum moisture content for compaction for silt with sand soil is approximately 14.5 percent, based on the ASTM D 1557 (Modified Proctor) results shown in Appendix B. Typically, silt and clay soil exhibit suitable moisture contents for compaction on the order of 10 to 20 percent. Further, the proctor curve provided in Appendix B indicates the on-site soil could feasibly be compacted to the specified compaction criteria with a moisture content range of about 3 percent above and below the optimum moisture content. This corresponds to an approximate moisture content range for compaction of 11.5 to 17.5 percent for the on-site silt and clay. The majority of moisture content test results are above 17.5 percent. This indicates most silt and clay soil excavated at the project site will require drying prior to its reuse as structural fill. This will require moisture conditioning and compaction effort to meet the 92 percent compaction requirement as discussed above.

Achieving uniform, near optimum moisture conditions or a moisture condition that will allow achieving the required compaction will become more difficult as the clay content of the soil increases. Drying the soil may require several types of equipment including bulldozers, tractors with discs and/or sheep's-foot rollers. In addition, we observed cobbles and boulders in the on-site silt and clay; specifically, a zone directly overlying basalt bedrock. The silt and clay will require processing to remove cobbles and boulders larger than 8 inches in diameter.

Shotrock

If basalt bedrock will be blasted or excavated, it can be reused as structural fill. However, we do not recommend mixing lifts of shotrock and on-site silt and clay. The on-site silt and clay will have a tendency to infiltrate the shotrock and piping and loss of soil fill density could occur. Therefore, we recommend shotrock reuse and placement be carefully planned in specific areas. If shotrock is used, it should be processed into a well-graded, 12-inch-minus mixture. This structural fill product should not contain large voids which could contribute to internal piping. Additionally, it may be required to separate the well-graded shotrock from the on-site silt and clay using geotextile fabric rated for the shotrock product having minimum properties provided in the *Geotextile* section of this report. Shotrock should be compacted using a "method" specification. This requires the shotrock be consolidated using a vibratory roller having a drum weight greater than 10 tons, or using a cage roller fastened to large bulldozer equipment such as a Caterpillar D-8 or Caterpillar D-9. In summary, STRATA should be retained to work with the contractor to verify the method specification requirements for the contractor's specific equipment at the onset of construction.

Earthwork Volume Criteria

STRATA provided preliminary earthwork, bulking and shrinkage factors to assist grading plan development. The bulking and shrinkage factors we provided in the email dated Friday, July 11, 2008 were based on assumptions for field compaction results as well as potential variations in proctor values across the entire site. As such, our recommendations provided below are only estimates. We reviewed our estimates relative to the Idaho Transportation Department (ITD) Materials Manual which provides estimated shrink and swell criteria for both silt and clay soil. The ITD Materials Manual provides approximate shrinkage factors for silt and clay as 17 percent and 10 percent, respectively. Our estimates using in-situ unit weight values compared to proctor values and specified compaction indicate the silt and clay may shrink on the order of 12 to 17 percent. The on-site silty sand and silty gravel soil will be extremely difficult to predict shrinkage and swell estimates given its appreciable boulder and cobble content.

Approximately 30 to 35 percent of the soil mass contains particles over 8 inches in diameter which cannot be used within silt and clay structural fills. The percentage of particles greater than 8 inches in diameter will vary throughout the soil profile. Generally, silty sand and silty gravel directly above basalt bedrock may realize an oversize content of 50 to 70 percent, while silt and clay soil near the ground surface may have an oversize content of 0 to 30 percent. Therefore, it appears reasonable to utilize the silt and clay shrinkage estimates provided above for the silty sand and silty gravel. However, we suggest any on-site soil which is reused as structural fill (silt, clay, silty sand, silty gravel, etc.) should account for an average oversize content of 25 to 35 percent. Based on our experience and discussions with civil engineering firms on previous projects, basalt bedrock that is excavated and replaced as structural fill be expected to typically swell 30 to 40 percent of its volume. Ultimately, basalt shotrock swell factors will be a function of the contractor's material processing, blasting, and excavation efforts. Consequently, these estimates of shrink/swell should be used by the reader as only estimates and not be relied on for bidding purposes.

Benching

We recommend structural fill placed on slopes steeper than 5H:1V be placed in horizontal lifts beginning at the toe of the slope and keyed into the slope by benching and terracing, as presented on Plate 4, *Sloped Fill Construction Schematic*. Specifically, we recommend each bench or terrace penetrate into the slope 2 to 4 feet laterally and not be more than 3 feet high. The requirement for extending benches into the slope is a mechanism to remove the upper few feet of the soil profile which has been subject to freeze, thaw and downward creep. This soil is not suitable to support sloped fills and should be keyed into the bench and incorporated into the structural fill being placed to construct the embankment. The bench width can be increased to accommodate the construction equipment and any slope variations, we also recommend constructing a larger "key" at the base of any sloped fill to allow construction staging and adequate width for compaction equipment. The initial key at the base of any excavation should be sloped into the hillside a minimum of 5H:1V and be a minimum of 10 feet in width. The exposed horizontal surface of any key, bench or terrace should consist of relatively undisturbed native soil prior to placing structural fill and should be prepared as recommended in the *Soil Subgrade Preparation* section above. If the contractor's means and methods significantly disturb the subgrade, the subgrade should be recompacted to structural fill requirements or deepened to undisturbed native soil or bedrock.

Wet Weather/Soil Construction

We strongly recommend earthwork construction take place during dry weather conditions. The clay and silt will be susceptible to pumping or rutting from heavy loads such as rubber-tired equipment or vehicles any time of the year. Sand and gravel soil containing more than 30 percent fines content will also be moisture-sensitive and difficult to compact if it is over optimum moisture content. Earthwork should not be performed immediately after rainfall or until soil can dry sufficiently to allow construction traffic without disturbing the subgrade. Earthwork must be completed by track-mounted equipment that reduces vehicular pressure applied to the soil if construction commences in wet areas before soil can dry. If the silt and clay subgrade is firm, but may be easily disturbed, the contractor may place an initial structural fill lift between 12 and 18 inches to help reduce the compaction energy on the sensitive subgrade. This thicker structural fill lift can only be installed over sensitive subgrades at STRATA's direction during construction. This initial thicker fill lift should be placed only after the contractor has attempted to moisture condition and recompact the native soil and was unsucessful. Whenever possible, the contractor should place structural fill lifts less than 12 inches as described and recommended in the *Structural Fill* section of this report.

Depending on precipitation, runoff and perched groundwater conditions we anticipate the soil will be slightly over optimum moisture content. The contractor should expect these conditions and be prepared to install runoff management facilities and to replace wet or disturbed soil with granular structural fill. Over-excavation and replacement in wet areas should only be allowed after moisture conditioning and recompaction has been attempted. Drying can be accomplished by ripping and aerating the wet soils during dry weather conditions. If construction takes place during wet weather conditions (not recommended), or the soil cannot achieve the required compaction, over-excavation to undisturbed, firm soil will be required following adequate efforts to moisture condition the soil. The over-excavation, whenever possible, should be completed with smooth blade equipment prior to replacing excavation with geotextile fabric and granular structural fill. Such over-excavations may utilize on-site silt and clay soil within the over-excavation, providing the on-site silt and clay is adequately moisture-conditioned and can achieve compaction requirements within the over-excavation. If on-site native soil is not available in over-excavations, granular structural fill or process shotrock should be used.

Areas that remain overly wet, subgrades near perched groundwater or subgrades that pump may need to be over-excavated and replaced with granular structural fill. In addition, the use of geotextiles and geogrids may be required to stabilize the subgrade and could reduce over-excavation quantities. Geotextiles and geogrids should conform to the

Geosynthetics section of this report. STRATA should be consulted before placing geotextile fabrics or geogrids. We recommend over-excavation criteria be determined during construction by STRATA, but typically should be anticipated to extend at least 1-foot.

After achieving subgrade, the contractor must take precautions to protect the subgrade from becoming disturbed or saturated. We recommend the contractor limit construction traffic to any prepared subgrades and reduce the subgrades' exposure to precipitation and water. Subgrades must be graded to aggressively direct surface water away from subgrades to avoid infiltration. Exposed subgrade soil that becomes soft or begins to pump should be removed to firm soil and replaced with structural fill as described above for over-excavations. We recommend earthwork specifications specifically identify the contractor's responsibility to protect and maintain prepared subgrades. It may improve project economy to retain STRATA to observe the subgrade preparation activities to identify any subgrade preparation techniques or construction activities which may be attributing to unstable subgrades and contributing for the need of over-excavations. Structural fill placement should never be attempted following a significant precipitation event. The subgrade should never be allowed to freeze or become saturated prior to fill placement. The final condition of the subgrade and careful construction procedures are critical to the long-term project performance.

Foundation Recommendations

We recommend the proposed pump station and headworks mechanical building be supported on conventional spread foundations bearing on basalt bedrock or native soil compacted to structural fill requirements. Foundations may also be supported on structural fill prepared as recommended in the *Structural Fill* section of this report. Foundation bearing surfaces should be free of loose soil, debris, snow, ice or standing water immediately prior to placing concrete for footings. STRATA should observe, test and document bearing surfaces prior to construction. If subsurface conditions different than those described in this report are encountered during foundation excavation, STRATA should be notified and provided an opportunity to re-evaluate our foundation design and construction recommendations.

We recommend exterior foundations be embedded at least 30 inches below finished grade to reduce the potential for frost action. Frost penetration in the Coeur d'Alene Lake area is estimated to vary from 28 to 32 inches depending upon the reference used. We used Federal Aviation Association data to estimate footing frost embedment. The above frost embedment should also be considered for utility embedment, depending upon their seasonal use. Interior footings should bear at least 18 inches below the final adjacent grade or interior slab on grade. Backfill soil placed in footing and utility trenches and against foundation walls should be placed and compacted as recommended in the *Structural Fill* section.

We recommend foundations be designed (sized) to achieve a relatively uniform bearing pressure. A minimum footing width of 16 inches should be used for foundation construction. Foundations bearing on compacted structural fill prepared as discussed above may be designed using an *allowable* soil bearing pressure of 3,000 pounds per square foot (psf) for dead load plus long-term live loads. The allowable bearing pressure may be increased by up to 30 percent to account for transient live loads such as wind or seismic accelerations.

If foundations are designed and constructed based on these recommendations, we estimate total settlement and differential settlement will be less than 1-inch and ½-inch, respectively. If foundation subgrades become disturbed or saturated prior to concrete placement and loose soil is not removed from footing excavations, settlements larger than those estimated may occur.

Lateral foundation loads will be resisted by friction against the foundation base. For sliding resistance at the base of footings, we recommend using a coefficient of sliding friction of 0.4 for mass concrete placed directly over native soil or compacted structural fill and 0.65 for mass concrete placed directly over undisturbed or recompacted bedrock. The above values are unfactored

Concrete Slabs

Floor slabs may be supported on grade if site preparation is accomplished as previously recommended. Slabs must be designed for the anticipated use and loading. We recommend slab-on-grade floors be underlain by at least 4 inches of crushed base course. The actual base course thickness could be greater and will depend on structural design requirements. Base course will provide structural support, a leveling course and some moisture protection for the slab. Base course placed below slabs should be compacted to structural fill requirements as presented above. If the above recommendations are followed, we recommend structural design using coefficient and *allowable* modulus of subgrade reaction (k) of 200 pounds per cubic inch (pci) for floor slab design.

Moisture migration through floor slabs can break down a floor covering, its adhesive or cause various other floor covering performance problems. Where interior floor slabs, floor coverings, equipment or other structures and materials above the slab must be protected from damage by moist floor conditions, we suggest a vapor retarder be installed. A vapor retarder should consist of thick, puncture resistant polyethylene sheeting covered with an additional 2-inch-thick layer of clean, coarse sand placed between the base course and the concrete slab-on-grade floor. If the plastic sheeting is not puncture proof, an additional 2 inches of sand should be placed as a cushion below the sheeting.

Form stakes or other sub-slab penetrations should never be allowed to penetrate the protective sheeting. Where penetrations must occur, plumbing and other sub-slab penetrations should be taped or sealed in accordance with the manufacturer's recommendations. Although these recommendations are used, water vapor migration through concrete floor slabs is still possible. Floor coverings should be selected accordingly and vapor retarder manufacturer recommendations should be strictly followed. Where vapor retarders are utilized, the flooring and concrete slab contractors as well as the plastic sheeting manufacturer should be consulted regarding additional slab cure time requirements and/or the potential for slab curling.

Slope Construction

We recommend constructed soil slopes be revegetated immediately after construction is complete. Slopes that are not revegetated will be subject to erosion, sloughing and slope failures. If adequate vegetative cover cannot be established immediately after construction is complete, we recommend erosion control measures be implemented and maintained to avoid excessive erosion and potential violation of local, state and federal erosion control and sedimentation regulations.

<u>Fill Slopes</u>

To evaluate planned slope configurations, we utilized the grading plans provided by you, our experience with similar subsurface conditions, and the results from laboratory testing and geotechnical analyses. Based on our analyses, we recommend fill slopes be constructed no steeper than 2H:1V. Soil slopes that have potential to be exposed to water maintained in detention, irrigation or unlined ponds and wetlands should be constructed no steeper than 3H:1V. Our opinion is slopes constructed steeper than recommended will be more susceptible to seasonal sloughing and erosion, as well as more significant risk of instability during wet periods of the year. Further, synthetic liners placed on slopes steeper than 3H:1V have the potential to slide over the silt and clay soil unless they are designed and anchored commensurate with the pond slopes and site conditions.

Cut Slopes

Based on our analyses and good construction practices, our opinion is soil cut slopes constructed no steeper than 1.5H:1V in native soil conditions provide a static safety factor of approximately 1.6. It should be noted that 1.5H:1V cut slopes will still have thin (less than 2 feet deep) surficial failures and erosion until vegetation is established. Due to the difficulty in establishing vegetation on steep slopes, we anticipate that continual maintenance such as cleaning of drainage ditches at the base of the cuts will be needed. In our opinion, to help re-establish vegetation, soil cut slopes must be constructed flatter than 2H:1V. Although not encountered during exploration, soil slopes that become exposed to seeps, springs or groundwater may not be stable at these inclinations and should be re-evaluated on a case-by-case basis where these conditions exist. We do not recommend synthetic liners be placed on slopes steeper than 3H:1V unless the liner system is designed and anchored accordingly.

Bedrock Cut Slopes

Excavations into basalt bedrock may be realized and will require the construction of permanent rock cut slopes. We recommend constructing permanent rock cut slopes at a maximum slope of 0.5H:1V. The bedrock's actual condition and fracture patterns will not be known until the time of construction and geometric contingencies must allow slopes in highly weathered or highly fractured rock to be laid back to flatter inclinations. Further, this cut slope geometry (0.5H:1V) assumes the bedrock cannot be excavated using the previously specified excavation equipment. Thus, the upper few feet of the bedrock may be required to be laid back at 2H:1V as with soil cut slopes. After rock cuts are performed and prior to final pond or roadway construction adjacent to rock cut slopes, hand or machine scaling (i.e., removal of loose rocks) should be performed to remove loose rock. In addition, if local unstable zones on the rock face are identified, mitigation methods such as the application of shotcrete, rock bolts/dowels, wire mesh or rockfall wire-net drapes may be required.

Surface and Subsurface Drainage

Any runoff from precipitation, snowmelt, seeps or springs must not be allowed to infiltrate at cut slopes, fill slopes, fill slope subgrades, or foundation and slab subgrades. Runoff or water migrating along the ground surface must be conveyed away from slopes and structures by an appropriately designed series of ditches, swales or other surface water management procedures. We do not recommend water be allowed to collect at the base of slopes or infiltrate soil beneath any fill slope. We recommend the ground surface outside of any structure be sloped a minimum of 5 percent away for a minimum of 10 feet to rapidly convey surface water or roof runoff away from foundations. Collected stormwater or runoff must not be allowed to daylight on constructed slopes. Stormwater should be routed away from disturbed soil areas and should be disposed of in a suitable location as determined by the site civil engineer.

In addition to the surface drainage requirements, we recommend any foundation be constructed with foundation drains. Foundation drains should never be connected to roof drains. Foundation drains should be constructed by placing a minimum 4-inch-diameter perforated pipe 2 to 4 inches below the base of any footing. The footing excavation should be backfilled around the pipe using free-draining soil such as pea gravel or drain rock. We recommend geotextile fabric be placed everywhere pea gravel or drain rock touches the native soil. Foundation drains should daylight a minimum of 20 feet outside any building footprint.

If the owner elects to forego the use of foundation drains, we recommend all foundation backfill consist of on-site silt and clay soil compacted to structural fill requirements. Compacted silt and clay can provide a low permeability cap to help reduce subsurface infiltration and route surface runoff away from the building and its' foundation. However, water can still infiltrate the foundation subgrade at the stemwall/backfill interface. If foundation drains are not installed, the potential for moisture migration below any structure's slab is increased. We recommend the owner carefully weigh the risk of omitting foundation drains from any structure, against the relatively low cost to install and construct foundation drains.

In addition to foundation drains, many lined pond designs incorporate underdrain systems. Underdrain systems are an efficient way of collecting and routing moisture migration below pond linings and daylighting such nuisance water away from the ponds to help reduce soil saturation and potential pond slope instability. Although STRATA did not observe seeps, springs or groundwater, these conditions could change with seasonal variations in infiltration, precipitation and especially changes to the site drainage characteristics. We observed test pit excavations in May, 2008 after an unusually harsh winter and wet spring. Thus, the lack of observed subsurface moisture at the time of excavation does not cause us to require pond underdrain systems. However, subsurface conditions below ponds may be different than as observed in test pits, and could negatively impact pond liners. Further, the above discussion also assumes pond liners will never leak. Given the above discussion, if the owner wishes to reduce their risk of subsurface moisture impacting pond liners, we recommend liner design incorporate an underdrain system.

A drainage system should include synthetic or graded aggregate drainage systems placed below the liner. Such systems should include drains extending directly uphill and downhill on any side slopes as well as perimeter drains and underdrains below the pond base. Underdrains and perimeter drains should be graded or sloped such that subsurface water is transmitted away from the pond liner and are daylighted to an appropriately selected location that does not adversely impact adjacent structures. We recommend a maximum drain spacing of 40 feet in any direction. This underdrain spacing is arbitrary as no subsurface moisture was observed and thus, we could not accomplish underdrain design. Many drainage system configurations are possible, and STRATA is available to consult with Brown and Caldwell regarding underdrain systems if the owner wishes to construct such secondary protection structures.

We recommend STRATA be retained to observe earthwork and benching procedures to help identify subsurface seeps or springs that may exist prior to placing structural fill for embankments or constructing cut slopes. It is possible seeps or springs may be encountered, that will require specialized drainage structures below embankments. Although we do not anticipate such requirements, variations in subsurface conditions are possible between exploration locations. STRATA should be consulted if subsurface seeps, springs or groundwater are identified below planned embankments during mass grading.

Seismicity

Generally, the most current version of the International Building Code (IBC) is utilized for structural design. Section 1615 of the 2003 IBC outlines the procedure for evaluating site ground motions and design spectral response accelerations. STRATA utilized site soil and geologic data and the project location to establish earthquake loading criteria at the site referencing Section 1615 of the 2003 IBC. Based on our understanding of site conditions and experience in the area of this project, we recommend a Site Class of "C" be utilized as a basis for structural seismic design. The Maximum Considered Earthquake (MCE) maps from the 2003 IBC were referenced to develop the MCE Response Spectra for Site Class C as presented below. This response spectrum assumes a 5 percent critical damping ratio in accordance with the IBC, Section 1615. A site specific study was not performed. The structural designer may use the spectral response at period T=0.09 to estimate peak ground acceleration at the site.

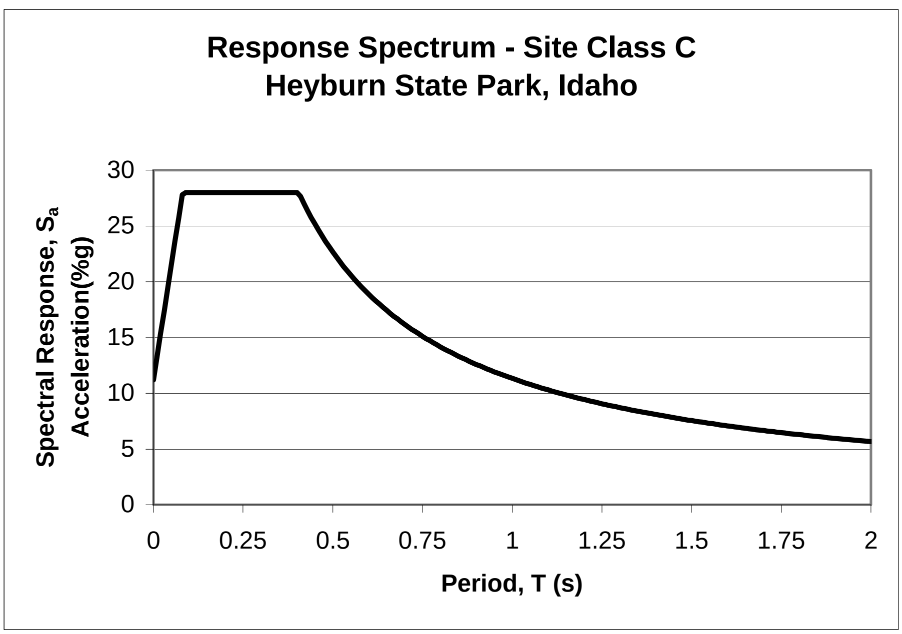


Figure 1. IBC MCE Response Spectrum, Heyburn State Park, Idaho

Corrosion

Generally, silt and clay soil in the Lake Coeur d'Alene area has a low to moderate soil corrosivity potential. To evaluate corrosivity at the site through direct laboratory testing, we accomplished a resistivity test in the on-site silt in TP-8 at 1 to 2 feet. The resistivity result was 7731 ohm-cm, which is considered a low to moderate corrosion potential for uncoated steel. We do not anticipate significant corrosion potential for buried, uncoated steel at the site. Additionally, Type I/II Portland cement is suitable for use at the site. We do not anticipate the requirement to use Type III Portland cement for corrosion protection.

Earthwork Geotextiles

This section is intended to recommend geotextile fabric properties, which may, or may not be required, depending upon the contractors means and methods. This section is not intended to address geosynthetics for pond liner design. Geotextile fabrics for the purpose of mass grading include woven geotextiles, non-woven geotextiles and geogrids. Where applicable, all geosynthetics should be placed directly on subgrades prepared as described herein and pulled taut. Woven geotextiles should have minimum puncture strength of 110 pounds (ASTM D 4833) and grab tensile strength of 250 pounds (ASTM D 4632). Non-woven geotextiles should be a minimum of 4 to 5 ounces per square yard and have a maximum apparent opening size equivalent to the No. 50 sieve (ASTM D 4751), minimum permittivity of 100 gallons per minute per square-foot (ASTM D 4491) and minimum puncture strength of 100 pounds (ASTM D 4833). Geogrids, if utilized, should consist of an extruded, polypropylene, biaxial geogrid with a minimum ultimate tensile strength of 1,200 pounds per foot placed at the over-excavated subgrade. Tensar BX1200 is an example of this type of geogrid. STRATA should be consulted to review geosynthetic applications.

ADDITIONAL RECOMMENDED SERVICES

Geotechnical Design Continuity

The information contained in this report is based on exploration, laboratory testing and partial development plans. Final design configurations and the actual subsurface conditions encountered during construction can significantly alter our opinions and geotechnical recommendations. Therefore, we recommend STRATA be retained to provide geotechnical continuity through design and construction. STRATA can also assist Brown and Caldwell by accomplishing plan and specification review to verify our recommendations are incorporated into final design. Further, we recommend you contact STRATA intermittently throughout the project design and bidding process to assist Brown and Caldwell and the owners in evaluating contractor's bids. STRATA is also available to provide quality assurance testing on the owner's behalf to verify geotechnical-related portions of the plans and specifications are followed during construction. STRATA would provide such services on a time and expense basis.

Construction Material Testing and Observation

We recommend STRATA be retained to observe geotechnical-related portions of construction to verify our recommendations are followed. STRATA is also available to provide earthwork observation and compaction testing on the owners behalf to verify our geotechnical recommendations are followed. STRATA can also provide observation of concrete, reinforcing steel, asphalt, aggregate placement and pond liner testing as needed. Our opinion is that involving the geotechnical consultant of record during construction helps reduce the potential for errors and also reduces costly contract changes during construction.

EVALUATION LIMITATIONS

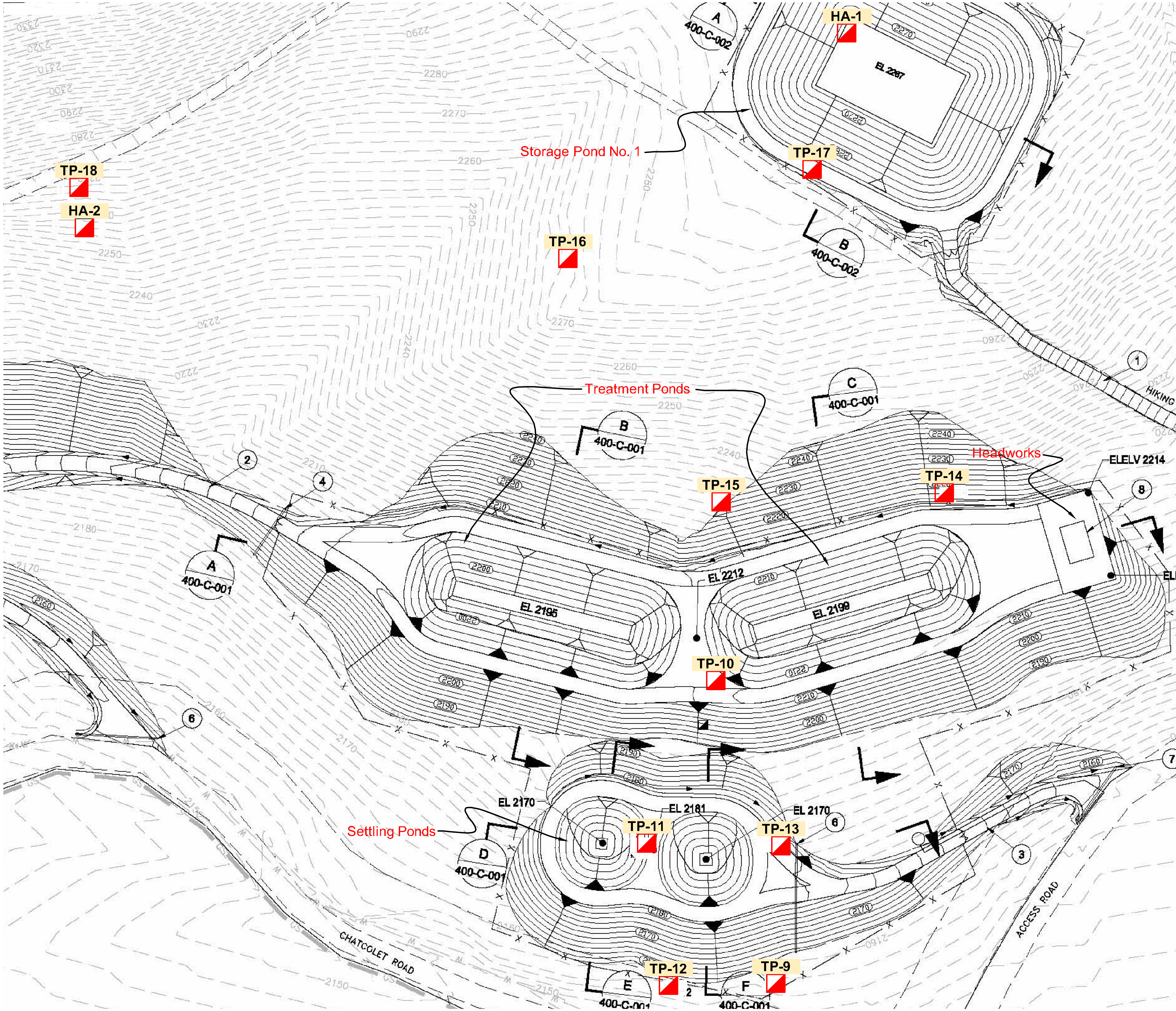
This report has been prepared to assist the planning and design of the proposed Central Sewage Collection and Treatment Facility to be located at Heyburn State Park in Benewah County, Idaho. Our services consist of professional opinions and recommendations made in accordance with generally accepted geotechnical engineering principles and practices as they exist at this time and in the area of this report. The geotechnical recommendations provided herein are based on the premise that an adequate program of tests and observations will be conducted by STRATA during construction to verify compliance with our recommendations and to confirm conditions between exploration locations. Follow-up during construction is an important part of the geotechnical design process. If we are not contacted to verify our geotechnical recommendations via providing material testing, observation and verification, we cannot be responsible for geotechnical-related design and construction errors or omissions. This acknowledgement is in lieu of all express or implied warranties.

This document was prepared for the proposed Central Sewage Collection and Treatment Facility project to be located at Heyburn State Park and specifically for Brown and

Caldwell. We do not authorize its use by any other individuals or firms other than the Idaho Department of Parks and Recreation or members of the design team. This report has been prepared specifically for the proposed construction described herein and for the Heyburn State Park site slated for project construction. This report cannot be extrapolated or used on any other sites or for any other construction without STRATA's review and written approval. Further, we understand this report may be incorporated into project specifications as a reference document. We understand Brown and Caldwell may clarify within the specifications that this report is not intended for reliance by bidding contractors to develop submittals. Accordingly, this report is intended to assist the design team in preparing project specifications and is intended for information only to bidding contractors or subcontractors.

The following plates and appendices accompany and complete this report:

Plate 1:	Site Plan – Area 1
Plate 2:	Test Pit Location Plan – Area 2
Plate 3:	Inset – Area 2
Plate 4:	Sloped Fill Construction Schematic
Appendix A:	USCS Explanation and Exploratory Test Pit Logs
Appendix B:	Laboratory Test Results



VICINITY MAP

NOT TO SCALE

LEGEND

TP-9 — Approximate Location of Test Pit Observed by STRATA on May 7th and 8th, 2008.

Note: Locations Were Not Surveyed and are Approximate

SCALE: 1 inch = 80 ft

SITE PLAN - AREA 1
Heyburn State Park
Benewah County, Idaho

STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

BROCAL C08025A | PLATE: 1

THIS PLAN COMPRISES A PORTION OF STRATA'S REPORT AND THE TEXT OF THE REPORT CONTAINS ESSENTIAL INFORMATION: BEFORE UTILIZING THIS PLAN FOR ANY PURPOSE WHATSOEVER, THE REPORT SHOULD BE READ COMPLETELY. THIS PLAN IS INTENDED TO HELP VISUALIZE THE INFORMATION PROVIDED IN THE REPORT. THESE LOCATIONS AND INFORMATION WERE ADDED TO EXISTING PLANS OF THE SITE PREVIOUSLY PREPARED BY OTHERS AND NO CHECK OF ACCURACY, CURRENCY, APPROPRIATENESS, ETC., OF INFORMATION PROVIDED BY OTHERS WAS PERFORMED, SINCE SUCH CHECKS WERE NOT PART OF STRATA'S SCOPE OF SERVICES.

Reference: Site Plan From Brown and Caldwell, Contract Drawings, Dated: 5/2008.

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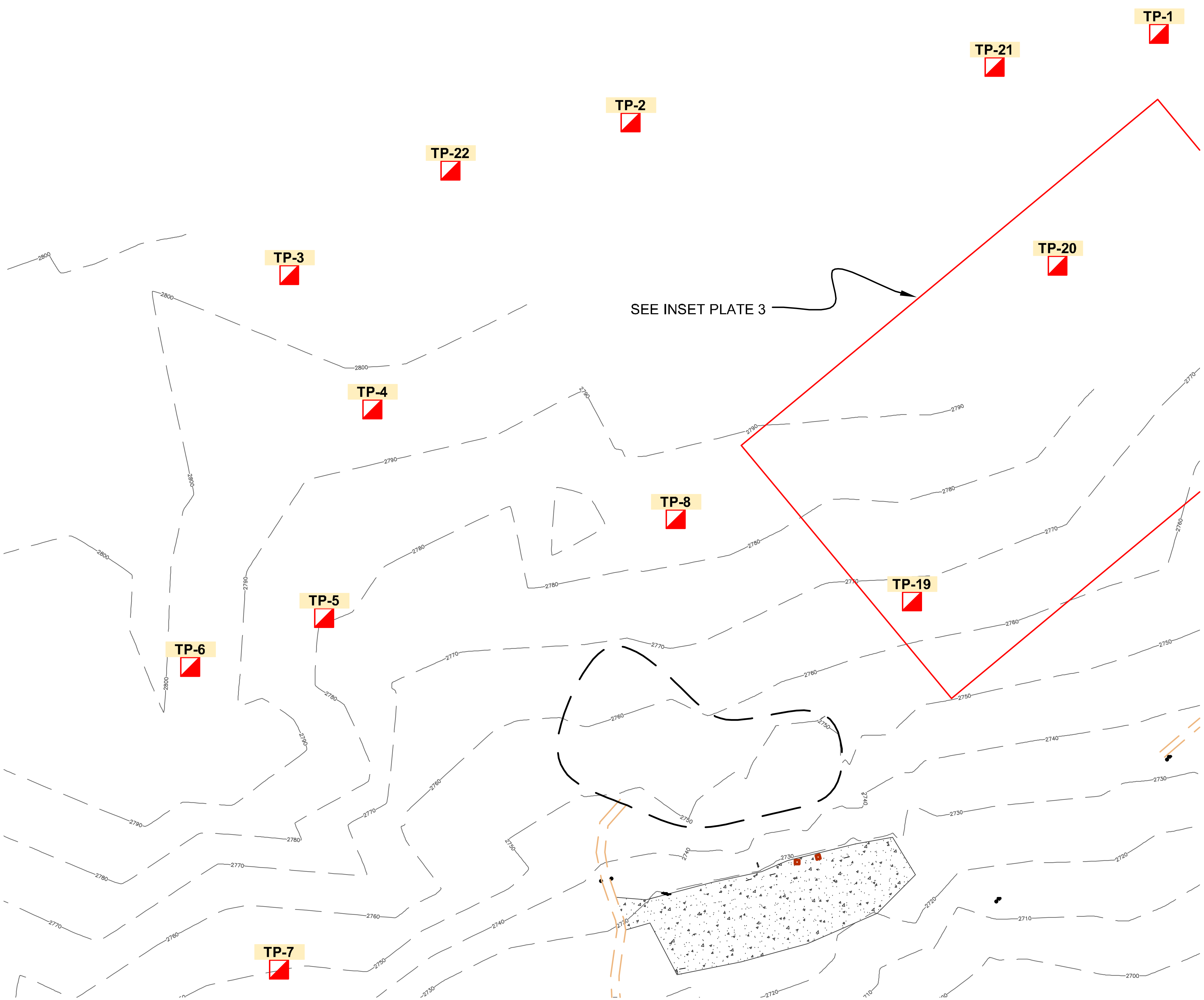

VICINITY MAP

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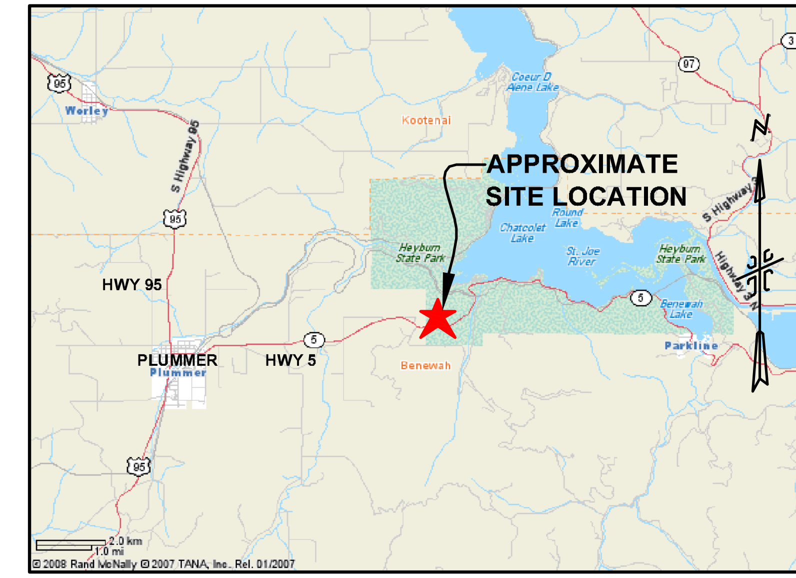

LEGEND

TP-19 Approximate Location of Test Pits Observed by STRATA on May 8, 2008.

Note: Locations Were Not Surveyed and are Approximate

0 75 150 300

SCALE: 1 inch = 150 ft

TEST PIT LOCATION PLAN
AREA - 2
Heyburn State Park
Benewah County, Idaho

STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

BROCAL C08025A | PLATE: 2

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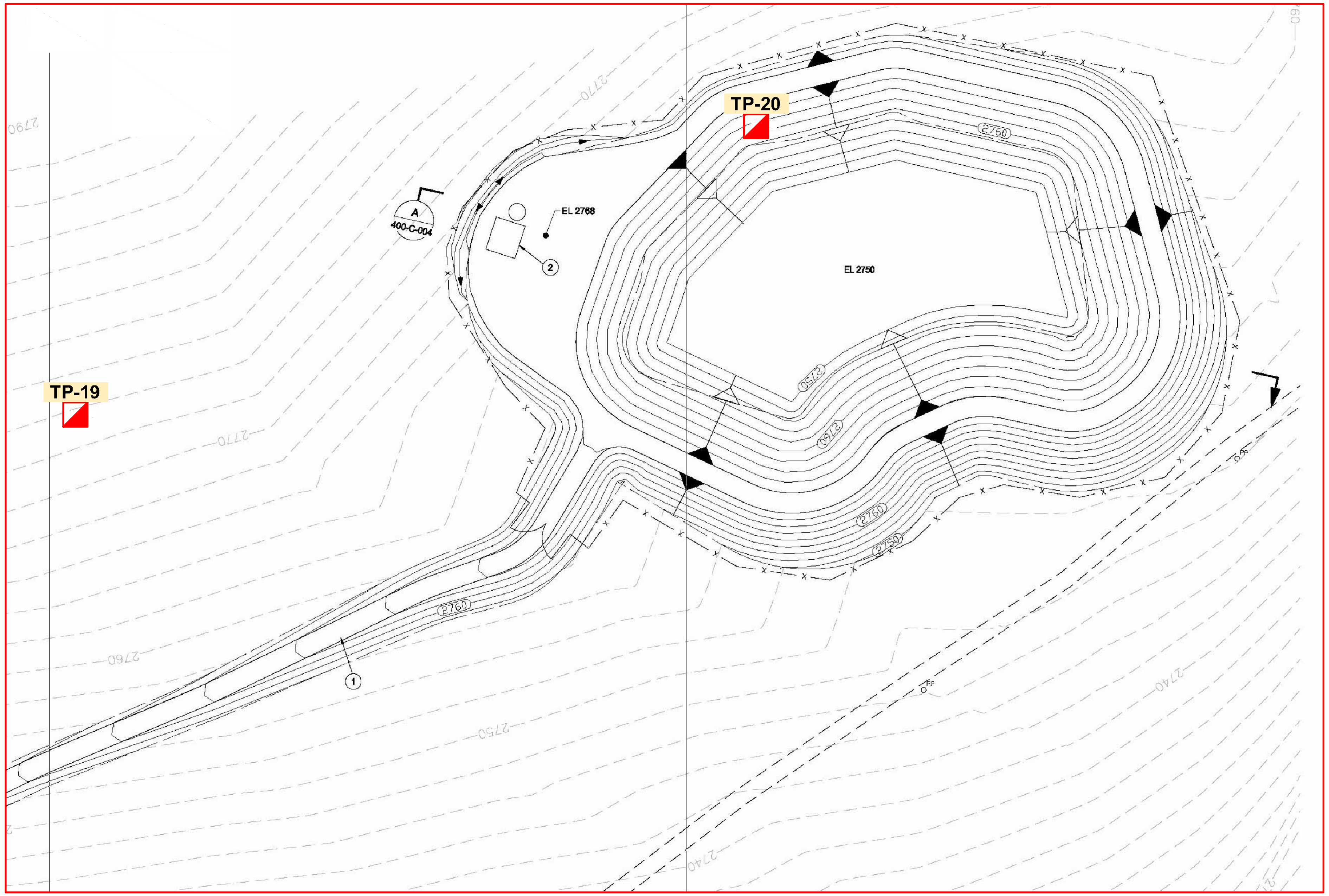
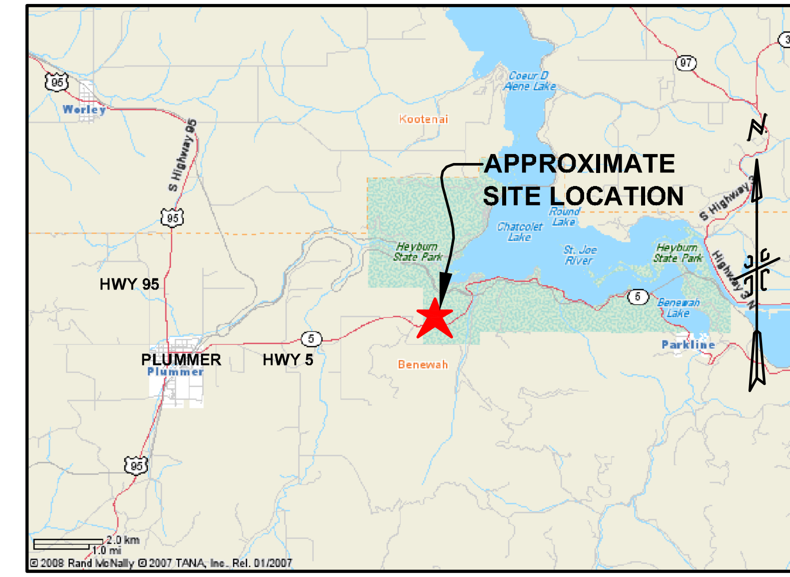
Reference: Site Plan From Crane Drafting Service, File: 13397–Strata Base.dwg, Dated: 6/2008.



VICINITY MAP

NOT TO SCALE



LEGEND

TP-19 Approximate Location of Test Pits Observed by STRATA on May 8, 2008.

NOTE:
This Plate is an Inset to Plate 2 for Area 2.

0 40 80 160
SCALE: 1 inch = 80 ft

INSET - AREA 2
Heyburn State Park
Benewah County, Idaho

STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

BROCAL C08025A | PLATE: 3

THIS PLAN COMPRISES A PORTION OF STRATA'S REPORT AND THE TEXT OF THE REPORT CONTAINS ESSENTIAL INFORMATION: BEFORE UTILIZING THIS PLAN FOR ANY PURPOSE WHATSOEVER, THE REPORT SHOULD BE READ COMPLETELY. THIS PLAN IS INTENDED TO HELP VISUALIZE THE INFORMATION PROVIDED IN THE REPORT. THESE LOCATIONS AND INFORMATION WERE ADDED TO EXISTING PLANS OF THE SITE PREVIOUSLY PREPARED BY OTHERS AND NO CHECK OF ACCURACY, CURRENCY, APPROPRIATENESS, ETC., OF INFORMATION PROVIDED BY OTHERS WAS PERFORMED, SINCE SUCH CHECKS WERE NOT PART OF STRATA'S SCOPE OF SERVICES.

Reference: Site Plan From Brown and Caldwell, Contract Drawings, Dated: June 2008

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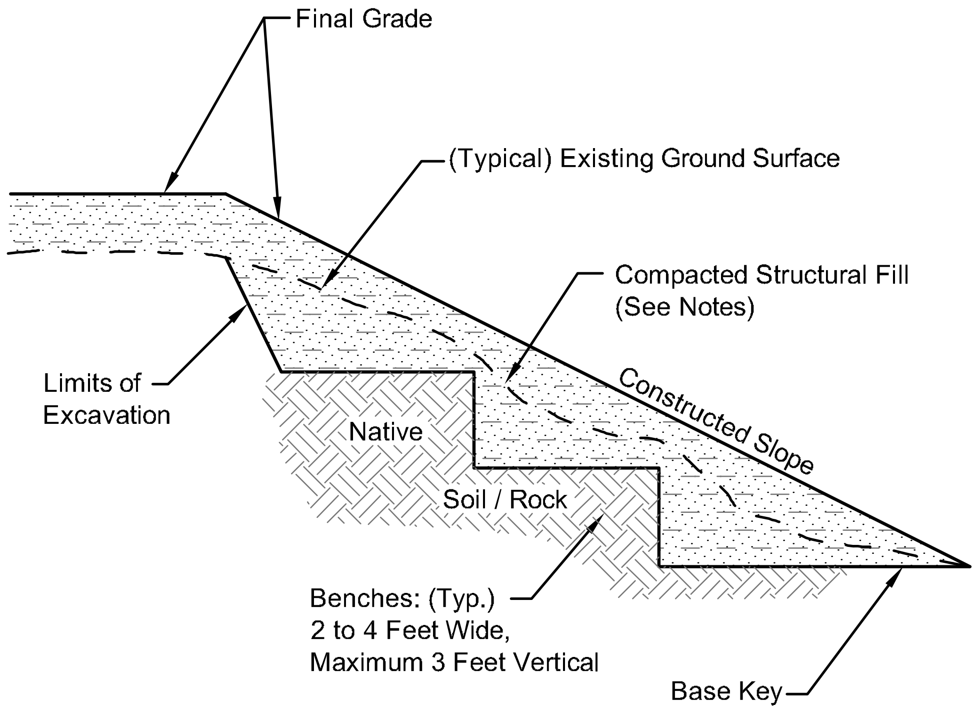

NOTES:

1. Structural Fill to be placed in maximum 12-inch, loose lifts and compacted to a minimum of 92% of the maximum dry density as determined by ASTM D -1557. All structural fill construction should conform to STRATA's recomendations in the reported text.

2. Benches maximum 3 feet vertical to 2 to 4 feet horizontal and constructed according to the *benching* section of the report.

3. Base key should be a minimum of 10 feet in width and prepared according to report text.

INFORMATIONAL ONLY (NOT TO SCALE)

SLOPED FILL CONSTRUCTION SCHEMATIC

STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

BROCAL C08025A	PLATE: 4

APPENDIX A

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
SILT with Sand (Native) — dark brown to tan, stiff, wet.	0–2	ML						1.5	Significant vegetation and organics observed to 6 inches BGS.
Basalt BEDROCK — gray, slightly weathered, slightly fractured to massive, vesicular.	2–2.3	RX							
Test pit terminated at 2.3 feet BGS due to bedrock refusal.									

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

Client: BROCAL	Test Pit Number: TP–1
Project: C08025A	Date Excavated: 5/08/08
Trackhoe: JD 490 D	Bucket Width: 3'
Depth to Groundwater: N.E.	Logged By: CMC

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

EXPLORATORY TEST PIT

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
SILT (Native) — dark brown to tan, stiff, wet.	0–2	ML		BG	87.1	23.6		1.5 2.0	Significant vegetation and organics observed to 10 inches BGS. Atterberg Limits: LL=31,PI=10
Basalt BEDROCK — gray, slightly weathered, slightly fractured to massive, vesicular.	2–2.5	RX							
Test pit terminated at 2.5 feet BGS due to bedrock refusal.									

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Client: BROCAL	Test Pit Number: TP–2	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/08/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CMC		**Sheet 1 of 1**

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
SILT (Native) — dark brown to tan, stiff, wet.	0–2	ML		BG				1.5 1.0	Significant vegetation and organics observed to 10 inches BGS.
Basalt BEDROCK — tan to dark gray, highly fractured, slightly weathered, dense.	2–2.5	RX							
Test pit terminated at 2.5 feet BGS due to bedrock refusal.									

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Client: BROCAL	Test Pit Number: TP—3	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	EXPLORATORY TEST PIT
Project: C08025A	Date Excavated: 5/08/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CMC		Sheet 1 of 1

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
SILT (Native) – dark brown to tan, stiff, wet.	0–2.5	ML		RG					Significant vegetation and organics observed to 10 inches BGS.
Silty GRAVEL with Sand and Cobbles (Colluvium) – dark reddish brown, medium dense, wet.	2.5–3	GM							
Basalt BEDROCK – tan to dark gray, moderately weathered, moderately fractured, vesicular.	3–3.2	RX							
Test pit terminated at 3.2 feet BGS due to bedrock refusal.									

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Client: BROCAL	Test Pit Number: TP–4	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/08/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CMC		**Sheet 1 of 1**

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
SILT (Native) — dark brown to tan, stiff, wet.	0–4	ML						1.5 1.0	Significant vegetation and organics observed to 10 inches BGS.
Basalt BEDROCK — tan to dark gray, moderately weathered, moderately fractured, vesicular.	4–4.5	RX							
Test pit terminated at 4.5 feet BGS due to bedrock refusal.									

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Client: BROCAL	Test Pit Number: TP—5	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/08/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CMC		**Sheet 1 of 1**

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT (Native) – dark brown to tan, stiff, wet.	0–2	ML		BG	65	29.2			Significant vegetation and organics observed to 10 inches BGS. Atterberg Limits: LL=39,PI=11
Lean CLAY (Alluvium) – reddish brown, stiff to hard, moist.	2–6.5	CL		BG	95	16.9		3.0 4.5+ 4.5+	Excavation difficult below 2.0 feet BGS. Atterberg Limits: LL=44,PI=27 ph=6.3
Test pit terminated at 6.5 feet BGS due to excavation refusal an hard clay.	6.5–15								

Client: BROCAL	Test Pit Number: TP–6	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/08/08	
Trackhoe: JD 490 D	Bucket Width: 3'	
Depth to Groundwater: N.E.	Logged By: CMC	**Sheet 1 of 1**

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Integrity from the Ground Up

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
SILT (Native) — dark brown to tan, stiff, wet.	0–2	ML						2.0	Significant vegetation and organics observed to 8 inches BGS.
Lean CLAY (Alluvium) — reddish brown, stiff to hard, moist.	2–11.5	CL		BLK				4.5+ 4.5+	
Basalt BEDROCK — tan to dark gray, moderately weathered, moderately fractured, vesicular.	11.5–12	RX							
Test pit terminated at 12 feet BGS due to bedrock refusal.									

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

Client: BROCAL	Test Pit Number: TP-7
Project: C08025A	Date Excavated: 5/08/08
Trackhoe: JD 490 D	Bucket Width: 3'
Depth to Groundwater: N.E.	Logged By: CMC

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Integrity from the Ground Up

EXPLORATORY TEST PIT

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Lean CLAY with Sand (Native) – dark brown to tan, stiff, wet.	1 2	ML		BLK	82	22.6		1.5 2.5 2.0	Significant vegetation and organics observed to 10 inches BGS. PH = 6.8 Resistivily = 7731 ohm.cm Percolation test performed at 1.5 feet BGS. Infiltration rate = 1.5 in/hr measured. Atterberg Limits: LL=47,PI=26
Silty GRAVEL with Sand (Colluvium) – dark reddish brown, medium dense, wet.	3	GM							
Basalt BEDROCK – tan to dark gray, moderately weathered, moderately fractured, vesicular.	4 5	RX							
Test pit terminated at 5.5 feet BGS due to bedrock refusal.	6 7 8 9 10 11 12 13 14 15								

Client: BROCAL	Pit Number: TP-8	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/08/08	
Trackhoe: JD 490 D	Bucket Width: 3'	
Depth to Groundwater: N.E.	Logged By: CMC	**Sheet 1 of 1**

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT (Native) – dark brown, soft to firm, moist.	0	ML							Significant vegetation and organics observed to 6 inches BGS.
SILT with Sand, Gravel, Cobbles and Boulders (Colluvium) – reddish brown, stiff, moist.	1 2 3	ML		BG BG	74	20.4	92.6		10% oversize from 0 to 4 feet Atterberg Limits: LL=21,PI=Non Plastic
CLAY with Gravel, Cobbles and boulders (Colluvium) – reddish brown, hard, moist.	4 5 6	CL		BG				3.5–4.0	Becomes indurated at 4 feet 30% oversize from 4 to 7 feet Boulders ranging from 12 to 18 inches Highly indurated at 6.5 to 7.0 feet
Test pit terminated at 7.0 feet BGS due to refusal on hard clay.	7 8 9 10 11 12 13 14 15								

Client: BROCAL	Pit Number: TP–9	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING *Integrity from the Ground Up*	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/07/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CW		**Sheet 1 of 1**

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT (Native) – dark brown, soft to firm, moist.		ML							Significant vegetation and organics observed to 6 inches BGS.
Sandy SILT with Gravel, Cobbles and Boulders (Colluvium) – reddish brown, stiff, moist.	1, 2, 3	ML		BG				0.5–0.75	30% boulders larger than 8 inches
Basalt BEDROCK – moderately weathered, moderately to highly fractured, very hard.	4, 5, 6	RX							Increasing bedrock density at 4.5 feet
Test pit terminated at 7.0 feet BGS due to bedrock refusal.	7, 8, 9, 10, 11, 12, 13, 14, 15								

Client: BROCAL	Pit Number: TP–10
Project: C08025A	Date Excavated: 5/07/08
Trackhoe: JD 490 D	Bucket Width: 3'
Depth to Groundwater: N.E.	Logged By: CW

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

EXPLORATORY TEST PIT

Sheet 1 of 1

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT (Native) — dark brown, soft to firm, moist.		ML							Significant vegetation and organics observed to 10 inches BGS.
Sandy SILT with Gravel, Cobbles and Boulders (Colluvium) — reddish brown, stiff, moist.	1 2 3 4 5	ML		BG				1.0–1.25	5 to 10% cobbles and boulders larger than 8 inches
Basalt BEDROCK — moderately weathered, moderately to highly fractured, very hard.	6 7	RX							
Test pit terminated at 8.0 feet BGS due to bedrock refusal.	8 9 10 11 12 13 14 15								

Client: BROCAL	Pit Number: TP–11	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/07/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CW		**Sheet 1 of 1**

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT (Native) – dark brown, soft to firm, moist.	0–1	ML							Significant vegetation and organics observed to 12 inches BGS.
Sandy SILT with Gravel, Cobbles and Boulders (Colluvium) – reddish brown, stiff, moist.	1–3	ML		BG					10 to 20% cobbles and boulders larger than 8 inches
Lean CLAY with Sand, Cobbles and Boulders (Colluvium) – tan, stiff, moist.	3–5.5	CL		BLK RG	71.6	27.1		2.0	30 to 40% cobbles and boulders larger than 8 inches from 3 to 5.5 feet Atterberg Limits: LL=35,PI=13
Basalt BEDROCK – moderately weathered, moderately to highly fractured, very hard.	5.5–9	RX							
Test pit terminated at 9.0 feet BGS due to bedrock refusal.	9–15								

Client: BROCAL	Pit Number: TP–12	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/07/08	
Trackhoe: JD 490 D	Bucket Width: 3'	
Depth to Groundwater: N.E.	Logged By: CW	**Sheet 1 of 1**

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT (Native) – dark brown, soft to firm, moist.	0–1	ML							Significant vegetation and organics observed to 12 inches BGS.
SILT with Sand, Gravel, Cobbles and Boulders (Colluvium) – reddish brown, stiff, moist.	1–5	ML		BG BLK	72	19.4		2.0	Atterberg Limits: LL=20,PI=Non Plastic ASTM D 1557 Results: Maximum density= 117 pcf Optimum moisture= 14.5%
Basalt BEDROCK – moderately weathered, moderately to highly fractured, very hard.	5–8	RX							
Test pit terminated at 8.0 feet BGS due to bedrock refusal.	8–15								

Client: BROCAL	Pit Number: TP–13
Project: C08025A	Date Excavated: 5/07/08
Trackhoe: JD 490 D	Bucket Width: 3'
Depth to Groundwater: N.E.	Logged By: CW

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

EXPLORATORY TEST PIT

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT (Native) – dark brown, soft to firm, moist.	0–1	ML							Moderate vegetation and organics observed to 12 inches BGS.
Sandy SILT with Gravel, Cobbles and Boulders (Colluvium) – reddish brown, stiff, moist.	1–7	ML		BG BLK BG	73.3	19.6		3.0 2.5	3.5 foot diameter boulder observed at about 2.0 feet 10% cobbles and boulders larger than 8 inches observed.
Basalt BEDROCK – moderately weathered, moderately to highly fractured, very hard.	7–9	RX							
Test pit terminated at 9.0 feet BGS due to bedrock refusal.	9								

Client: BROCAL	Pit Number: TP–14	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/07/08	
Trackhoe: JD 490 D	Bucket Width: 3'	
Depth to Groundwater: N.E.	Logged By: CW	**Sheet 1 of 1**

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT (Native) – dark brown, soft to firm, moist.		ML							Significant vegetation and organics observed to 6 inches BGS.
Sandy SILT with Gravel, Cobbles and Boulders (Colluvium) – reddish brown, stiff, moist.	1	ML							
	2			BG		20.7		4.5+	5 to 10% cobbles and boulders larger than 8 inches observed
	3								Up to 2 foot diameter boulders observed
	4							1.5 2.5	
	5			BG					
	6								Increased boulder and cobble content and density at 6.0 feet BGS. 30% cobbles and boulders larger than 8 inches observed
Practical refusal on very dense colluvial boulders at 7.0 feet BGS.	7								
	8								
	9								
	10								
	11								
	12								
	13								
	14								
	15								

Client: BROCAL	Pit Number: TP–15	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING *Integrity from the Ground Up*	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/07/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CW		**Sheet 1 of 1**

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT with Cobbles (Native) – dark brown, soft to firm, moist.	1	ML							Moderate vegetation and organics observed to 18 inches BGS.
Silty GRAVEL with Sand and Cobbles (Colluvium) – brown, dense to medium dense, moist.	2 3 4 5	GM							Boulders from 4 to 5 feet in diameter observed 80% cobbles and boulders larger than 8 inches observed.
Practical refusal on large boulders at 6.0 feet BGS.	6 7 8 9 10 11 12 13 14 15								

Client: BROCAL	Pit Number: TP–16	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/07/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CW		**Sheet 1 of 1**

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT with Cobbles (Native) – dark brown, soft to firm, moist.	0 – 0.5	ML							Significant vegetation and organics observed to 6 inches BGS.
Sandy SILT with Gravel, Cobbles and Boulders (Colluvium) – reddish brown, stiff, moist.	0.5 – 7	ML		BLK/BG				1.5 2.0	
Silty SAND with Gravel and Cobbles (Alluvium) – light brown, dense to very dense, moist.	7 – 15.5	SM		BLK BG					Moderately to highly indurated
Test pit terminated at 15.5 feet BGS.									

Client: BROCAL	Pit Number: TP–17
Project: C08025A	Date Excavated: 5/07/08
Trackhoe: JD 490 D	Bucket Width: 3'
Depth to Groundwater: N.E.	Logged By: CW

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING
Integrity from the Ground Up

EXPLORATORY TEST PIT

Sheet 1 of 1

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT with Cobbles (Native) – dark brown, soft to firm, moist.	0–1	ML							Moderate vegetation and organics observed to 12 inches BGS.
Sandy SILT with Gravel, Cobbles and Boulders (Colluvium) – reddish brown, stiff, moist.	1–2.5	ML		BG					
Silty GRAVEL with Sand and Cobbles (Colluvium) – brown, dense to medium dense, moist.	2.5–9	GM							70% cobbles and boulders larger than 8 inches starting at 2.5 feet Boulders to 2.0 feet in diameter observed 80% cobbles and boulders larger than 8 inches observed
Test pit terminated at 9.0 feet BGS. due to trackhoe access limitations	9–15								

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Client: BROCAL	Pit Number: TP–18	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/07/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CW		**Sheet 1 of 1**

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
SILT (Native) – dark brown to tan, stiff, wet.	0–2	ML		BLK					Significant vegetation and organics observed to 6 inches BGS. Percolation test performed at 1.5 feet BGS. Infiltration rate = 0.6 in/hr measured.
Silty GRAVEL with Sand and Cobbles – dark reddish brown, medium dense, wet.	2–3	GM		BLK					
Basalt BEDROCK – tan to dark gray, highly fractured, slightly weathered, dense.	3–6	RX							Overlying silt has infiltrated the basalt fractures
Test pit terminated at 6.0 feet BGS due to bedrock refusal.	6–15								

Client: BROCAL	Pit Number: TP–19	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/08/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CMC		**Sheet 1 of 1**

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
SILT (Native) – dark brown to tan, stiff, wet.	1 2	ML							Significant vegetation and organics observed to 10 inches BGS.
Silty GRAVEL with Sand – dark reddish brown, medium dense, wet.	3	GM							
Basalt BEDROCK – tan, moderately weathered, highly fractured.	4	RX							
Test pit terminated at 5.0 feet BGS due to bedrock refusal.	5 6 7 8 9 10 11 12 13 14 15								

Client: BROCAL	Pit Number: TP–20	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/08/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CMC		**Sheet 1 of 1**

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
SILT (Native) — dark brown to tan, stiff, wet.	0–2.5	ML						1.5	Significant vegetation and organics observed to 8 inches BGS.
Basalt BEDROCK — gray, slightly weathered, slightly fractured to massive, vesicular.	2.5–2.7	RX							
Test pit terminated at 2.7 feet BGS due to bedrock refusal.									

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Client: BROCAL	Pit Number: TP—21	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	**EXPLORATORY TEST PIT**
Project: C08025A	Date Excavated: 5/08/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CMC		**Sheet 1 of 1**

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
SILT (Native) – dark brown to tan, stiff, wet.	0–2	ML						1.5	Significant vegetation and organics observed to 6 inches BGS.
Basalt BEDROCK – gray, slightly weathered, slightly fractured to massive, vesicular.	2–2.5	RX							
Test pit terminated at 2.5 feet BGS due to bedrock refusal.									

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Client: BROCAL	Pit Number: TP–22	STRATA GEOTECHNICAL ENGINEERING & MATERIALS TESTING Integrity from the Ground Up	EXPLORATORY TEST PIT
Project: C08025A	Date Excavated: 5/08/08		
Trackhoe: JD 490 D	Bucket Width: 3'		
Depth to Groundwater: N.E.	Logged By: CMC		Sheet 1 of 1

USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT with Gravel, Cobbles and Boulders (Native) – brown, soft to firm, moist.	0–5	ML							Moderate vegetation and organics observed to 8 inches BGS.
Test pit refused on boulder or cobble at 5.0 feet BGS.	5–15								

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Client: BROCAL	Test Pit Number: HA–1
Project: C08025A	Date Excavated: 5/7/08
Backhoe: JD 490D	Auger Diameter: 3"
Depth to Groundwater: N.E.	Logged By: CWW

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Integrity from the Ground Up

EXPLORATORY TEST PIT

Sheet 1 of 1

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USCS Description	DEPTH (In Feet)	USCS CLASS	SYMBOL	SAMPLE Type	% Passing No. 200 sieve	Moisture Content (%)	Dry Density (pcf)	Pocket Penetro-meter(tsf)	REMARKS Note: BGS = Below Ground Surface
Sandy SILT with Cobbles (Native) – dark brown, soft to firm, moist.	1 2	ML							Moderate vegetation and organics observed to 10 inches BGS.
Test pit refused on boulder or cobble at 2.5 feet BGS.	3 4 5 6 7 8 9 10 11 12 13 14 15								

Client: BROCAL	Test Pit Number: HA–2
Project: C08025A	Date Excavated: 5/7/08
Backhoe: JD 490D	Auger Diameter: 3"
Depth to Groundwater: N.E.	Logged By: CWW

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Integrity from the Ground Up

EXPLORATORY TEST PIT

Sheet 1 of 1

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UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL NAMES
COARSE GRAINED SOILS	GRAVELS	CLEAN GRAVELS		GW	Well–Graded Gravel, Gravel–Sand Mixtures.
				GP	Poorly–Graded Gravel, Gravel–Sand Mixtures.
		GRAVELS WITH FINES		GM	Silty Gravel, Gravel–Sand–Silt Mixtures.
				GC	Clayey Gravel, Gravel–Sand–Clay Mixtures.
	SANDS	CLEAN SANDS		SW	Well–Graded Sand, Gravelly Sand.
				SP	Poorly–Graded Sand, Gravelly Sand.
		SANDS WITH FINES		SM	Silty Sand, Sand–Silt Mixtures.
				SC	Clayey Sand, Sand–Clay Mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50%			ML	Inorganic Silt, Sandy or Clayey Silt.
				CL	Inorganic Clay of Low to Medium Plasticity, Sandy or Silty Clay.
				OL	Organic Silt and Clay of Low Plasticity.
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50%			MH	Inorganic Silt, Mica–ceous Silt, Plastic Silt.
				CH	Inorganic Clay of High Plasticity, Fat Clay.
				OH	Organic Clay of Medium to High Plasticity.
				PT	Peat, Muck and Other Highly Organic Soils.

BORING LOG SYMBOLS	GROUNDWATER SYMBOLS	TEST PIT LOG SYMBOLS
Standard 2–Inch OD Split–Spoon Sample	Groundwater After 24 Hours	BG Baggie Sample
California Modified 3–Inch OD Split–Spoon Sample	(7–3–07) Indicates Date of Reading	BK Bulk Sample
Rock Core	Groundwater at Time of Drilling	RG Ring Sample
Shelby Tube 3–Inch OD Undisturbed Sample		

Shorthand Notation:
BGS = Below Existing Ground Surface
N.E. = None Encountered

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BROCAL C08025A

APPENDIX B

MOISTURE-DENSITY RELATIONSHIP CURVE

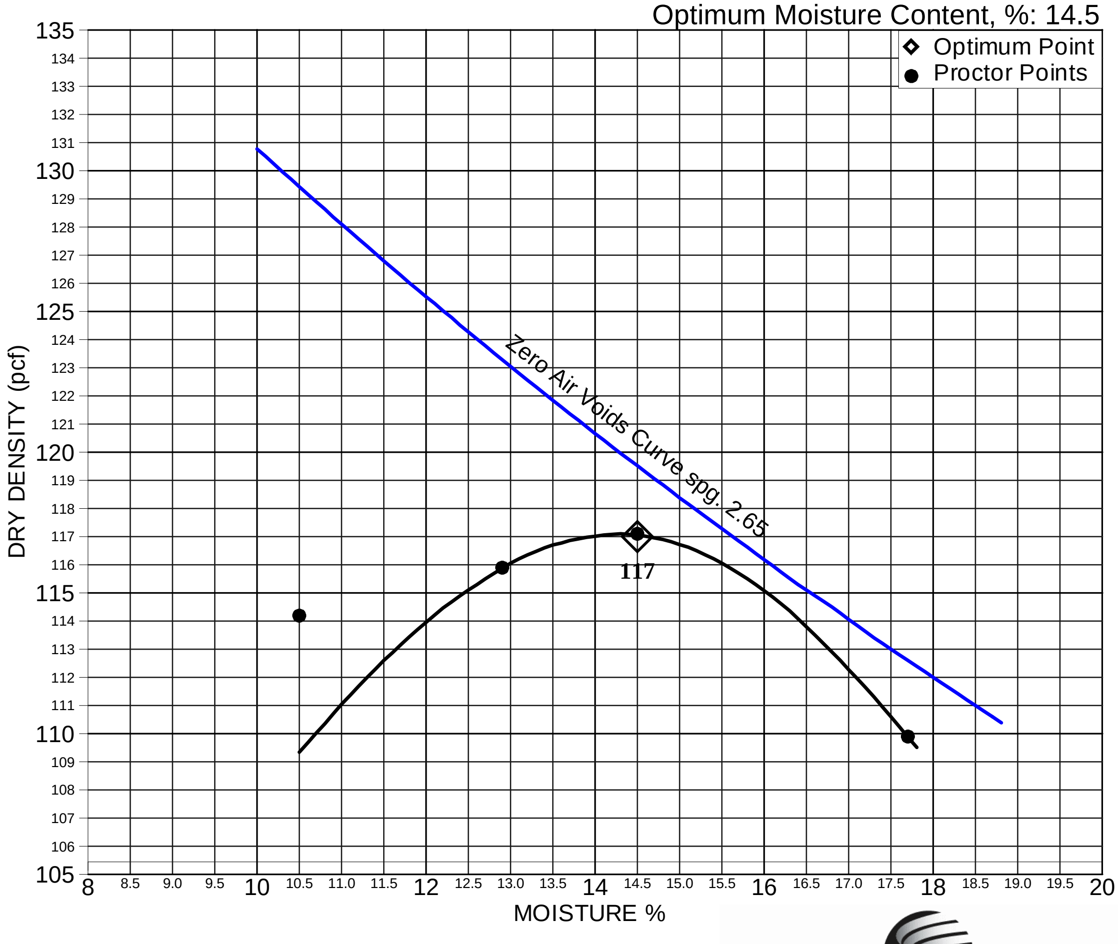
ASTM D-1557
Method A

Project: Heyburn State Park
Client: Brown & Caldwell
File Name: BROCAL C08025A
Date Tested: 6/16/08 By: MR
Sample Number: B8L1131C
Sample Location: TP-13 @ 1.5 - 2'
Sample Description: Silt with Sand
Soil Tempered: Yes
Rammer Type: Manual
Atterberg Limits: LL = 20, PI = N/P
In-Situ Moisture = 19.4%

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
3 inch		
2 inch	100	
3/4 inch		
3/8 inch		
#4 screen	97	100
#200 screen	72	

Maximum Dry Density, pcf : 117.0
Optimum Moisture Content, %: 14.5



Reviewed By Adrian [signature]

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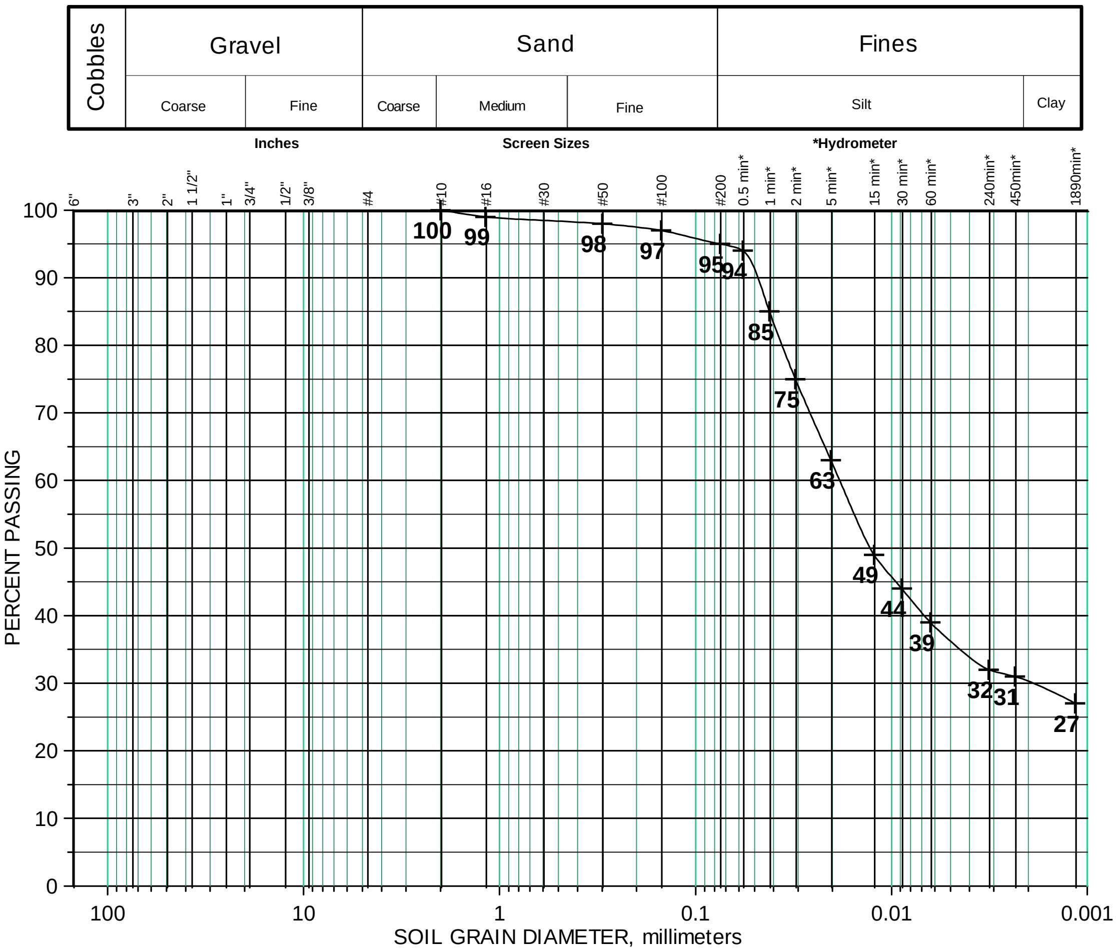
GRADATION ANALYSIS

ASTM D422

Project: Heyburn State Park
Client: Brown & Caldwell
File: BROCAL C08025A
Sample No.: B8L1131A
Sample Location: TP-6 @ 3 - 3.5'
Description: Lean Clay
Date Received: 6/9/08
Date tested: 6/10/08 By: AMH

In-Situ Moisture = 16.9%
Atterberg Limits:
LL = 44, PI = 27
pH = 6.3



Reviewed by: Adrian Vasconez

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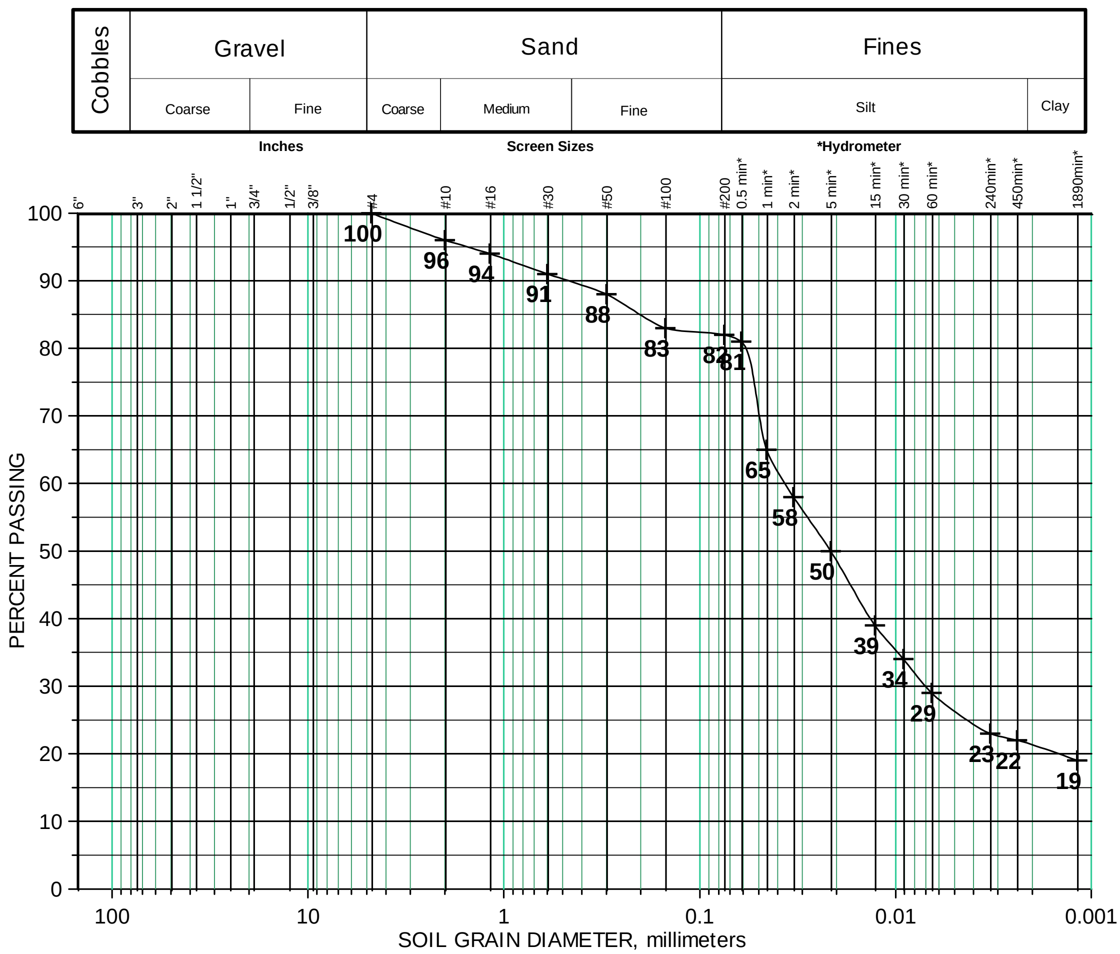
GRADATION ANALYSIS

ASTM D422

Project: Heyburn State Park
Client: Brown & Caldwell
File: BROCAL C08025A
Sample No.: B8L1131E
Sample Location: TP-23 @ 1 - 1.5'
Description: Lean Clay
Date Received: 6/9/08
Date tested: 6/10/08 By: AMH

In-Situ Moisture = 22.6%
Atterberg Limits:
LL = 47, PI = 26



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Integrity from the Ground Up

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